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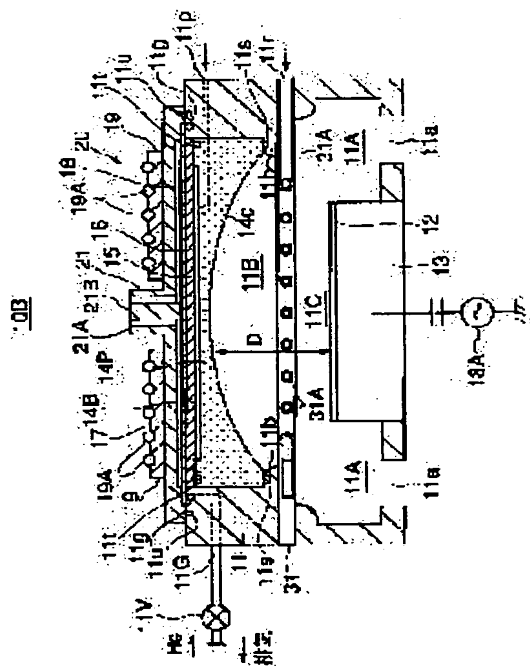
(54) PLASMA PROCESSOR

(57)Abstract:
PROBLEM TO BE SOLVED: To compensate the reduction of a plasma density on the periphery of a substrate processed by a microwave plasma processor.
SOLUTION: A shower plate or a plasma permeable window facing a substrate to be processed has a concave surface facing the substrate.



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CLAIMS

[Claim(s)]
[Claim 1] So that it may be formed with an outer wall and the processed substrate on said maintenance base may be met on said processing container with the processing container equipped with the maintenance base holding a processed substrate, and the exhaust air system combined with said processing container The microwave transparency aperture prepared as said some of outer walls, and the plasma gas feed zone which supplies plasma gas into said processing container, It consists of a microwave antenna formed on said processing container corresponding to said microwave. Said microwave transparency aperture Plasma treatment equipment with which the inside of the side which meets said processed substrate is characterized by having the concave surface configuration in which spacing between the flat surfaces which are in agreement with said processed substrate front face decreases toward the direction outside of a path of said microwave transparency aperture.
[Claim 2] Said spacing is plasma treatment equipment according to claim 1 characterized by decreasing continuously toward the direction outside of a path of said microwave transparency aperture.
[Claim 3] Said spacing is plasma treatment equipment according to claim 2 characterized by decreasing smoothly toward the direction outside of a path of said microwave transparency aperture.
[Claim 4] Said spacing is plasma treatment equipment according to claim 2 or 3 characterized by decreasing linearly toward the direction outside of a path of said microwave transparency aperture.
[Claim 5] Said spacing is plasma treatment equipment according to claim 2 or 3 characterized by decreasing in nonlinear toward the direction outside of a path of said microwave transparency aperture.
[Claim 6] Said spacing is plasma treatment equipment according to claim 1 characterized by decreasing stair-like toward the direction outside of a path of said microwave transparency aperture.
[Claim 7] Said spacing is plasma treatment equipment according to claim 1 characterized by decreasing toward the direction outside of a path of said microwave transparency aperture only in the periphery of said microwave transparency aperture.
[Claim 8] Said microwave transparency aperture is plasma treatment equipment given [among claims 1-7 characterized by the external surface which counters said inside consisting of a flat side] in any 1 term.
[Claim 9] Said microwave transparency aperture is plasma treatment equipment given [among claims 1-8 characterized by constituting said plasma gas feed zone which has a plasma gas path inside and emits plasma gas into said processing container] in any 1 term.
[Claim 10] Said microwave transparency aperture is plasma treatment equipment according to claim 9 characterized by having two or more openings which are open for free passage to said plasma gas path.
[Claim 11] A microwave transparency aperture is plasma treatment equipment according to claim 10 which is close to the cover plate which constitutes some outer walls of said processing

container, and said cover plate, is formed, and is characterized by consisting of a shower plate which has two or more openings which are open for free passage to said plasma gas path and this.
[Claim 12] Said microwave transparency aperture is plasma treatment equipment according to claim 10 or 11 characterized by consisting of a precise ceramic.
[Claim 13] Said microwave transparency aperture is plasma treatment equipment according to claim 9 characterized by consisting of porous media.
[Claim 14] Said microwave transparency aperture is plasma treatment equipment according to claim 9 characterized by consisting of a cover plate which constitutes said some of processing containers, and a shower plate which consists of porous media formed by being close to said cover plate.
[Claim 15] Said porous media are plasma treatment equipment according to claim 13 or 14 characterized by consisting of a sintering ceramic.
[Claim 16] Said plasma gas feed zone is plasma treatment equipment given [among claims 1-8 characterized by consisting of tubing connectable with the source of plasma gas formed in said processing container outer wall] in any 1 term.
[Claim 17] Said microwave transparency aperture is plasma treatment equipment according to claim 16 characterized by consisting of a precise ceramic.
[Claim 18] Furthermore, plasma treatment equipment given [among claims 1-17 characterized by preparing a raw gas feed zone between said processed substrates and said sources of plasma gas] in any 1 term.
[Claim 19] Said raw gas feed zone is plasma treatment equipment according to claim 18 characterized by having the plasma path which passes the plasma, a raw gas path connectable with the source of raw gas, and nozzle opening of a large number which were open for free passage to said raw gas path.
[Claim 20] Plasma treatment equipment given [among claims 1-19 characterized by including the RF generator furthermore connected to said maintenance base] in any 1 term.
[Claim 21] Said microwave antenna is plasma treatment equipment given [among claims 1-20 characterized by consisting of a radial line slot antenna] in any 1 term.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] Generally especially this invention relates to microwave plasma treatment equipment with respect to plasma treatment equipment.
[0002] A plasma treatment process and plasma treatment equipment are close to 0.1 micrometers called the so-called deep submicron component in recent years or a deep subquarter micron component, or are the overly indispensable technique for manufacture of a detailed-ized semiconductor device, and manufacture of the high resolution flat-surface display containing a liquid crystal display of having the gate length not more than it.
[0003] Although the excitation method of more various plasma than before is used as plasma treatment equipment used for manufacture of a semiconductor device or a liquid crystal display, parallel monotonous mold high-frequency excitation plasma treatment equipment or inductive-coupling mold plasma treatment equipment is especially common. However, the plasma formation of plasma treatment equipment of these former is uneven, and since the field where electron density is high is limited, performing a uniform process over the whole processed substrate surface, big processing speed, i.e., throughput, has the difficult trouble. Especially this problem becomes serious when processing the substrate of a major diameter. And with the plasma treatment equipment of these former, since electron temperature is high, a damage arises in the semiconductor device formed on a processed substrate, and that the metal contamination by sputtering of a processing interior wall is large etc. has some essential problems. For this reason, it is becoming difficult to fill the severe demand to the further detailed-izing of a semiconductor device or a liquid crystal display and improvement in the further productivity with conventional plasma treatment equipment.
[0004] The microwave plasma treatment equipment using the high density plasma excited by microwave electric field on the other hand, without using a direct-current magnetic field conventionally is proposed. For example, microwave is emitted in a processing container from the plane antenna (radial line slot antenna) which has the slot of a large number arranged so that uniform microwave might be generated, and the plasma treatment equipment of a configuration of ionizing the gas in a vacuum housing by this microwave electric field, and exciting the plasma is proposed. For example, refer to the JP,9-63793,A official report. It is possible to be able to realize a high plasma consistency over the large field directly under an antenna with the microwave plasma excited by such technique, and to perform uniform plasma treatment for a short time. And with the microwave plasma formed by this technique, in order to excite the plasma by microwave, electron temperature is low, and damage metallurgy group contamination of a processed substrate can be avoided. Since the still more uniform plasma also on a large area substrate can be excited easily, it can respond also to the production process of a semiconductor device and the manufacture of a large-sized liquid crystal display using the diameter semi-conductor substrate of macrostomia easily.
[0005]
[Description of the Prior Art] Drawing 1 (A) and (B) show the configuration of the conventional microwave plasma treatment equipment 100 using this radial line slot antenna. However, it is

drawing in which drawing 1 (A) shows the sectional view of microwave plasma treatment equipment 100, and drawing 1 (B) shows the configuration of a radial line slot antenna.
[0006] With reference to drawing 1 (A), microwave plasma treatment equipment 100 has the processing room 101 exhausted from two or more exhaust air ports 116, and the maintenance base 115 holding the processed substrate 114 is formed all over said processing room 101. Since uniform exhaust air of said processing room 101 is realized, space 101A is formed in the perimeter of said maintenance base 115 in the shape of a ring, it is regular intervals like, namely, said processing room 101 can be exhausted to homogeneity through said space 101A and the exhaust air port 116 by [which open said two or more exhaust air ports 116 for free passage to said space 101A] forming in axial symmetry to a processed substrate.
[0007] On said processing room 101, the tabular shower plate 103 which it became [plate] a location corresponding to the processed substrate 114 on said maintenance base 115 from the low loss dielectric, and had much openings 107 formed in it as some outer walls of said processing room 101 is formed through the seal ring 109, and the cover plate 102 which consists of a low loss dielectric still as well as the outside of said shower plate 103 is formed through another seal ring 108.
[0008] The path 104 of plasma gas is formed in the top face at said shower plate 103, and each of two or more of said openings 107 is formed so that it may be open for free passage to said plasma gas path 104. furthermore, inside said shower plate 103 The supply path 108 of the plasma gas which is open for free passage to the plasma gas supply port 105 established in the outer wall of said processing container 101 is formed. The plasma gas supplied to said plasma gas supply port 105, such as Ar and Kr Said opening 107 is supplied through said path 104 from said supply path 108, and it is substantially emitted to space 101B of said shower plate 103 directly under of said processing container 101 interior by uniform concentration from said opening 107.
[0009] On said processing container 101, further, it estranges 4-5mm from said cover plate 102, and the radial line slot antenna 110 which has the radial plane shown in drawing 1 (B) is formed in the outside of said cover plate 102. It connects with the external source of microwave (not shown) through coaxial waveguide 110A, and said radial line slot antenna 110 excites the plasma gas emitted to said space 101B by the microwave from said source of microwave. Atmospheric air is filled up with the clearance between said cover plate 102 and the radial plane of the radial line slot antenna 110.
[0010] Said radial line slot antenna 110 Flat disk-like body of antenna 110B connected to the outside waveguide of said coaxial waveguide 110A, It consists of radiation plate 110C which had slot 110b of a large number which intersect perpendicularly with much slot 110a and this which were formed in opening of said body of antenna 110B, and which show drawing 1 (B) formed. Between said body of antenna 110B, and said radiation plate 110C, late phase plate 110D which thickness becomes from a fixed dielectric plate is inserted.
[0011] In the radial line slot antenna 110 of this configuration, although the microwave to which electric power was supplied from said coaxial waveguide 110 advances between body of antenna 110B of the shape of said disk, and radiation plate 110C with breadth to radial, wavelength is compressed by operation of said late phase plate 110D in that case. then, the wavelength of the microwave which does in this way and advances to radial — corresponding — said slots 110a and 110b — concentric circular — and the plane wave which has a circularly-polarized wave can be substantially emitted in the perpendicular direction by forming so that it may intersect perpendicularly mutually at said radiation plate 110C.
[0012] The uniform high density plasma is formed in space 101B of said shower plate 103 directly under by using this radial line slot antenna 110. Thus, the metal contamination which electron temperature is low, therefore a damage does not arise in the processed substrate 114, and originates in sputtering of the container wall of the processing container 101 does not produce the formed high density plasma.
[0013] With the plasma treatment equipment 100 of drawing 1 , further between said shower plates 103 and processed substrates 114 among said processing container 101 The structure 111 is formed. the conductor which had the nozzle 113 of a large number which supply raw gas

through the raw gas path 112 formed into said processing container 101 from the external source of raw gas (not shown) formed — the raw gas with which each of said nozzle 113 was supplied — said conductor — it emits to space 101C between the structure 111 and the processed substrate 114. said conductor — opening of magnitude which passes efficiently the plasma formed in said space 101B among said adjoining nozzles 113 and 113 by diffusion from said space 101B to said space 101C is formed in the structure 111.
[0014] then — such — said conductor — when raw gas is emitted to said space 101C through said nozzle 113 from the structure 111, the emitted raw gas is excited by the high density plasma formed in said space 101B, and it is performed, without [without uniform plasma treatment moreover makes efficient and a high speed damage the component structure on a substrate and a substrate on said processed substrate 114, and] polluting a substrate. the microwave emitted from said radial line slot antenna 110 on the other hand — this conductor — it is prevented with the structure 111 and the processed substrate 114 is not damaged
[0015]
[Problem(s) to be Solved by the Invention] by the way, with the conventional plasma treatment equipment 100 of drawing 1 (A) and (B) Since spacing between said shower plates 103 and processed substrates 114 is narrow, Although very uniform plasma treatment becomes possible even if the continuous and stable plasma style to the direction of a path of the shower plate 103 is formed in said space 101B and 101C and said processed substrate 114 is a diameter substrate of macrostomia On the other hand, when the pressure in said processing container 101 declines, the problem to which a plasma consistency tends to fall especially in the periphery of the shower plate 103 arises. For example, when the pressure in the processing container 101 falls to 300 or less mTorrs in Ar ambient atmosphere, in the periphery of the shower plate 103, a plasma consistency falls greatly. Diffusion of the dissociated electron is promoted and this is considered to originate in disappearing by the internal surface of the processing container 101, when the pressure in the processing container 101 declines. When it falls below to the cut-off consistency which requires a plasma consistency, it becomes impossible to maintain the plasma, since the cut-off consistency of the plasma is 7.5x1010cm-3. Microwave will be directly impressed to the processed substrate 114, and the fall of the plasma consistency in this shower plate 103 periphery not only causes the fall of processing speed, but produces the problem which carries out induction of the damage.
[0016] Then, this invention makes it a general technical problem to offer the new and useful plasma treatment equipment which solved the conventional technical problem.
[0017] The more concrete technical problem of this invention is to offer the plasma treatment equipment in which uniform processing is possible over the whole processed substrate front face also in low processing pressure.
[0018]
[Means for Solving the Problem] The processing container equipped with the maintenance base which this invention is formed with an outer wall as the above-mentioned technical problem was indicated to claim 1, and holds a processed substrate, So that the processed substrate on said maintenance base may be met on said processing container with the exhaust air system combined with said processing container The microwave transparency aperture prepared as said some of outer walls, and the plasma gas feed zone which supplies plasma gas into said processing container, It consists of a microwave antenna formed on said processing container corresponding to said microwave. Said microwave transparency aperture With the plasma treatment equipment with which the inside of the side which meets said processed substrate is characterized by having the concave surface configuration in which spacing between the flat surfaces which are in agreement with said processed substrate front face decreases toward the direction outside of a path of said microwave transparency aperture As indicated to claim 2, or said spacing As indicated to the plasma treatment equipment according to claim 1 characterized by decreasing continuously toward the direction outside of a path of said microwave transparency aperture, or claim 3, said spacing As indicated to the plasma treatment equipment according to claim 2 characterized by decreasing smoothly toward the direction outside of a path of said microwave transparency aperture, or claim 4, said spacing As indicated to the plasma

treatment equipment according to claim 2 or 3 characterized by decreasing linearly toward the direction outside of a path of said microwave transparency aperture, or claim 5, said spacing With the plasma treatment equipment according to claim 2 or 3 characterized by decreasing in nonlinear toward the direction outside of a path of said microwave transparency aperture As indicated to claim 6, or said spacing As indicated to the plasma treatment equipment according to claim 1 characterized by decreasing stair-like toward the direction outside of a path of said microwave transparency aperture, or claim 7, said spacing With the plasma treatment equipment according to claim 1 characterized by decreasing toward the direction outside of a path of said microwave transparency aperture only in the periphery of said microwave transparency aperture As indicated to claim 8, or said microwave transparency aperture With plasma treatment equipment given in any 1 term among claims 1-7 characterized by the external surface which counters said inside consisting of a flat side As indicated to claim 9, or said microwave transparency aperture With plasma treatment equipment given in any 1 term among claims 1-8 characterized by constituting said plasma gas feed zone which has a plasma gas path inside and emits plasma gas into said processing container As indicated to claim 10, or said microwave transparency aperture As indicated to the plasma treatment equipment according to claim 9 characterized by having two or more openings which are open for free passage to said plasma gas path, or claim 11, a microwave transparency aperture It is close to the cover plate which constitutes some outer walls of said processing container, and said cover plate, and is prepared. With the plasma treatment equipment according to claim 9 characterized by consisting of a shower plate which has two or more openings which are open for free passage to said plasma gas path and this As indicated to claim 12, with or the plasma treatment equipment according to claim 8 or 11 characterized by said microwave transparency aperture consisting of a precise ceramic As indicated to claim 13, or said microwave transparency aperture As indicated to the plasma treatment equipment according to claim 9 characterized by consisting of porous media, or claim 14, said microwave transparency aperture With the plasma treatment equipment according to claim 9 characterized by consisting of a cover plate which constitutes said some of processing containers, and a shower plate which consists of porous media formed by being close to said cover plate As indicated to claim 15, or said porous media As indicated to the plasma treatment equipment according to claim 13 or 14 characterized by consisting of a sintering ceramic, or claim 16, said plasma gas feed zone With plasma treatment equipment given in any 1 term among claims 1-8 characterized by consisting of tubing connectable with the source of plasma gas formed in said processing container outer wall As indicated to claim 17, or said microwave transparency aperture With the plasma treatment equipment according to claim 16 characterized by consisting of a precise ceramic As indicated to claim 18, further or between said processed substrates and said sources of plasma gas As indicated to plasma treatment equipment given in any 1 term, or claim 19 among claims 1-17 characterized by preparing a raw gas feed zone, said raw gas feed zone With the plasma treatment equipment according to claim 18 characterized by having the plasma path which passes the plasma, a raw gas path connectable with the source of raw gas, and nozzle opening of a large number which were open for free passage to said raw gas path With or plasma treatment equipment given in any 1 term among claims 1-19 characterized by including the RF generator further connected to said maintenance base as indicated to claim 20 Or as indicated to claim 21, said microwave antenna is solved with plasma treatment equipment given in any 1 term among claims 1-20 characterized by consisting of a radial line slot antenna.

According to [operation] this invention, by forming a concave surface in the side which meets the processed substrate of said shower plate, spacing between the shower plate inferior surfaces of tongue and processed substrate front faces in which the high density plasma is formed in a processed substrate periphery decreases, and the fall of the plasma consistency in a shower plate periphery is compensated. Consequently, also when low-pressure plasma treatment, such as etching, is performed, the stable and uniform plasma is maintained [near the processed substrate front face]. Moreover, ignition of the plasma is also promoted by this configuration. Stabilization of the plasma by this concave surface formation is applicable also to the configuration which omitted not only a configuration but the raw gas feed zone which

prepared the raw gas feed zone between a processed substrate and a plasma gas feed zone.
[0019] Although it is possible to use the precise ceramic member which had opening of a large number which were open for free passage to a plasma gas path and this formed as a shower plate which has this concave surface, it is also possible to use a porosity ceramic member instead of said precise ceramic member. Although these shower plates are close to the precise cover plate which constitutes a nothing plasma transparency aperture and some processing container outer walls are established, it is also possible to form said crevice in the microwave transparency aperture itself further in this invention, and to introduce plasma gas all over said processing room with tubing etc. separately, without using a shower plate.
[0020] Since cooling of the shower plate which adhesion with a microwave antenna could secure easily that the external surface which counters the inside which makes said concave surface by the shower plate or microwave transparency aperture by this invention was a flat side, and minded the antenna is attained, it is advantageous.
[0021]
[Embodiment of the Invention] [1st example] drawing 2 (A) and (B) show the configuration of the microwave plasma treatment equipment 10 by the 1st example of this invention.
[0022] With reference to drawing 2 (A), said microwave plasma treatment equipment 10 The processing container 11, It is prepared in said processing container 11, and the maintenance base 13 which consists of AlN or aluminum 2O3 which holds the processed substrate 12 by the electrostatic chuck, and which was preferably formed of the isotropic pressure inflatable flexible bag technique (HIP) between heat is included. In said processing container 11, at least two exhaust air port 11a is preferably formed by **** symmetric relation at three or more places at space 11A surrounding said maintenance base 13 to the processed substrate 12 on regular intervals 13, i.e., said maintenance base. Said processing container 11 minds this exhaust air port 11a, and is exhausted and decompressed by an irregular-pitch inequality inclination screw pump etc.
[0023] Said processing container 11 consists of an austenitic stainless steel which contains aluminum preferably, and the protective coat which consists of an aluminum oxide by oxidation treatment is formed in the internal surface. Moreover, the shower plate 14 of the shape of a disk which it consisted [shape] of precise aluminum 2O3 formed by the HIP method, and had much nozzle opening 14A formed is formed in the part corresponding to said processed substrate 12 as said some of outer walls among the outer walls of said processing container 11. 14 is formed using the aluminum2O3 shower plateY2O3 formed by this HIP method as sintering acid, and has the very big thermal conductivity as a ceramic to which porosity reaches 30 W/m-K excluding pore or a pinhole substantially at 0.03% or less.
[0024] It is equipped with said shower plate 14 through seal ring 11s on said processing container 11, and the cover plate 15 which consists of precise aluminum 2O3 further formed of the same HIP processing on said shower plate 14 is formed through seal ring 11t. Crevice 14B which is open for free passage at each of said nozzle opening 14A to the side which touches said cover plate 15 of said shower plate 14, and becomes plasma gas passage is formed, and said crevice 14B is open for free passage to another plasma gas passage 14C which is open for free passage to plasma gas inlet-port 11p which was formed in the interior of said shower plate 14, and was formed in the outer wall of said processing container 11.
[0025] In order that said shower plate 14 may control abnormality discharge into the part which was formed in the wall of said processing container 11 and which ******s, is held by section 11b and holds said shower plate 14 among said overhang section 11b, the radius of circle is formed.
[0026] Then, after the plasma gas supplied to said plasma gas inlet-port 11p, such as Ar and Kr, carries out sequential passage of the passage 14C and 14B of said shower plate 14 interior, it is uniformly supplied into space 11B of said shower plate 14 directly under through said opening 14A.
[0027] The slot plate 16 of the shape of a disk which had many slots 16a and 16b which are close to said cover plate 15, and are shown in drawing 3 (B) formed on said cover plate 15, The body 17 of an antenna of the shape of a disk holding said slot plate 16, The radial line slot antenna 20 constituted with the late phase plate 18 which consists of low loss dielectric

materials of aluminum [which was pinched between said slot plates 16 and said bodies 17 of an antenna] 2O3, Si3N4, SiON, or SiO2 grade is formed. It is equipped with said radial slot line antenna 20 through seal ring 11u on said processing container 11, and the microwave whose frequency is 2.45GHz or 8.3GHz is supplied to said radial line slot antenna 20 from the external source of microwave (not shown) through the coaxial waveguide 21 which has a rectangle or a circular cross section. The supplied microwave is emitted into said processing container 11 through said cover plate 15 and the shower plate 14 from the slots 16a and 16b on said slot plate 16, and excites the plasma in space 11B of said shower plate 14 directly under in the plasma gas supplied from said opening 14A from it. In that case, said cover plate 15 and the shower plate 14 are formed of aluminum 2O3, and act as an efficient microwave transparency aperture. In order to avoid that the plasma is excited in said plasma gas passage 14A-14C in that case, said plasma gas is held in said passage 14A-14C at the pressure of about 6666Pa - 13332Pa (about 50 to 100 Torr).

[0028] In order to raise the adhesion of said radial line slot antenna 20 and said cover plate 15, 11g of ring-like slots is formed in a part of top face of said processing container 11 which engages with said slot plate 16 with the microwave plasma treatment equipment 10 of this example. By exhausting 11g of these slots through exhaust air port 11G which were open for free passage to this The clearance formed between said slot plates 16 and cover plates 15 is decompressed, and an atmospheric pressure enables it to push said radial line slot antenna 20 against said cover plate 15 firmly. Although the slots 16a and 16b formed in said slot plate 16 are included, a clearance may be formed in this clearance of various reasons of irregularity with cover-plate 15 detailed front face etc. besides it. The closure of this clearance is carried out by seal ring 11u between said radial line slot antennas 20 and processing containers 11.

[0029] By furthermore filling up the clearance between said slot plates 16 and said cover plates 15 with inert gas with small molecular weight through said exhaust air port 11G and 15g of slots, transportation of the heat from said cover plate 15 to said slot plate 16 can be promoted. As this inert gas, it is desirable that thermal conductivity, large moreover, uses high helium of ionization energy. When filling up said clearance with helium, it is desirable to set it as the pressure of 0.8 atmospheric-pressure extent. With the configuration of drawing 3 , bulb 11V are connected to said exhaust air port 11G for exhaust air of 15g of said slots, and restoration of 15g [of slots] inert gas.

[0030] Outside waveguide 21A is connected to the body 17 of an antenna of the shape of said disk among said coaxial waveguide 21A, and central conductor 21B is connected to said slot plate 16 through opening formed in said slow wave plate 18. Then, the microwave supplied to said coaxial waveguide 21A is emitted from said slots 16a and 16b, going on between said bodies 17 of an antenna and slot plates 16 in the direction of a path.

[0031] Drawing 2 (B) shows the slots 16a and 16b formed on said slot plate 16.

[0032] With reference to drawing 2 (B), said slot 16a is arranged by concentric circular, and, similarly slot 16b which goes to this direct is formed in concentric circular corresponding to each slot 16a. Said slots 16a and 16b are formed at spacing corresponding to the wavelength of the microwave compressed into radial [of said slot plate 16] with said late phase plate 18, and as a result, microwave turns into an approximate plane wave from said slot plate 16, and is emitted. Since said slots 16a and 16b are formed by the relation relation and mutual cross at right angles in that case, the microwave emitted by doing in this way forms the circularly-polarized wave containing two polarization components which intersect perpendicularly.

[0033] With the plasma treatment equipment 10 of this example, the front face of the side which meets said processed substrate 12 of said shower plate 14 forms the curve side of a concave surface configuration, and the spacing D between the flat surfaces which are in agreement with the front face of said shower plate 14 and processed substrate 12 as a result decreases smoothly toward the method of the outside of the improvement in the method of a radius of said shower plate 14. That is, said concave surface configuration is formed by the curved surface symmetrical with a shaft, and in order that said spacing D may decrease in the periphery of said processed substrate 12, the problem of a fall of the plasma consistency in this processed substrate periphery is solved.

[0034] Thereby, with said plasma treatment equipment 10, even if it performs plasma treatment with the need of carrying out by hypobaric environment-ization, such as dry etching, a plasma consistency does not fall below to a cut-off consistency, and the plasma is maintained by stability and can avoid problems, such as disappearance of the plasma in processed substrate 12 periphery, damage on the substrate by microwave, or a fall of processing speed.
[0035] Furthermore with the plasma treatment equipment 10 of drawing 2 (A), the cooling block 19 which had cooling water path 19A formed is formed on said body 17 of an antenna, and the heat accumulated in said shower plate 14 is absorbed through said radial line slot antenna 20 by cooling said cooling block 19 with the cooling water in said cooling water path 19A. It lets the cooling water which said cooling water path 19A is formed in the shape of a spiral on said cooling block 19, and eliminated dissolved oxygen by carrying out bubbling of the H2 gas preferably, and controlled the oxidation reduction potential pass.
[0036] moreover, with the microwave plasma treatment equipment 10 of drawing 2 (A) Among said processing container 11 between said shower plates 14 and processed substrates 12 on said maintenance base 13 The raw gas supply structure 31 of having raw gas path 31A of the shape of a grid which raw gas is supplied from raw gas inlet 11r prepared in the outer wall of said processing container 11, and emits this from much raw gas nozzle orifice section 31B (refer to drawing 3) is established. Desired uniform substrate processing is made in space 11C between said raw gas supply structures 31 and said processed substrates 12. Plasma oxidation processing, plasma nitriding treatment, plasma acid nitriding treatment, plasma-CVD processing, etc. are included in this substrate processing. Moreover, it is possible to perform reactive ion etching to said processed substrate 12 by supplying etching gas, such as fluorocarbon gas which is [6 / C4F8, C5F8, / C4F] easy to dissociate, and F system or Cl system, from said raw gas supply structure 31 to said space 11C, and impressing high-frequency voltage to said maintenance base 13 from RF generator 13A.
[0037] with the microwave plasma treatment equipment 10 by this example, adhesion of a reaction by-product etc. in a processing container wall avoids the outer wall of said processing container 11 by heating to 150-degree about C temperature -- having -- a day -- about 1 time of dry-cleaning **** -- it is things and stabilizing and operating is possible regularly.
[0038] Drawing 4 is the bottom view showing the configuration of the raw gas supply structure 31 in the configuration of drawing 2 (A).
[0039] With reference to drawing 4 , it consists of conductors containing Mg, such as aluminum alloy and aluminum addition stainless steel, and said grid-like raw gas path 31A is connected to said raw gas inlet 11r in raw gas supply-port 31R, and said raw gas supply structure 31 emits raw gas to homogeneity at said space 11C from raw gas nozzle orifice section 31B of a large number by which inferior-surface-of-tongue formation was carried out. Moreover, opening 31C which passes the raw gas contained in the plasma or the plasma is formed between raw gas path 31A which adjoins said raw gas supply structure 31. When forming said raw gas supply structure 31 with a Mg content aluminum alloy, it is desirable to form the fluoride film in a front face. Moreover, when forming said raw gas supply structure 31 by aluminum addition stainless steel, it is desirable to form the passive state film of an aluminum oxide in a front face. With the plasma treatment equipment 10 by this invention, since the electron temperature in the plasma which is excited and which is excited is low, the incidence energy of the plasma is small, and the problem which sputtering of this raw gas supply structure 31 is carried out, and metal contamination produces in the processed substrate 12 is avoided. Said raw gas supply structure 31 can also be formed with ceramics, such as an alumina.
[0040] Said grid-like raw gas path 31A and raw gas nozzle orifice section 31B are prepared so that a little larger field than the processed substrate 12 shown in drawing 4 with the broken line may be covered. By establishing this raw gas supply structure 31 between said shower plates 14 and processed substrates 12, plasma excitation of the raw gas, such as material gas and etching gas, is carried out, and this raw gas by which plasma excitation was carried out enables it to process to homogeneity.
[0041] In forming said raw gas supply structure 31 with conductors, such as a metal, said raw gas supply structure 31 forms the short circuit side of microwave by setting up shorter than the

wavelength of said microwave said spacing between grid-like raw gas path 31A. In this case, the microwave excitation of the plasma is produced in said space 11B, and raw gas is activated by the plasma diffused from said excitation space 11B in space 11C including the front face of said processed substrate 12.

[0042] Since supply of raw gas is uniformly controlled by the microwave plasma treatment equipment 10 by this example by using the raw gas supply structure 31, even when the problem of superfluous dissociation in processed substrate 12 front face of raw gas can be solved and the large structure of an aspect ratio is formed in the front face of the processed substrate 12, it is possible to carry out desired substrate processing even in the inner part of this high aspect structure. That is, microwave plasma treatment equipment 10 is effective in manufacture of many generations' semiconductor device with which the design Ruhr differs.

[0043] In plasma treatment equipment 10B of drawing 5 , it is possible by introducing various oxidization gas and nitriding gas, material gas, and etching gas from said raw gas supply structure 13 to be low temperature, to deposit various high quality film on homogeneity all over the front face of said processed substrate 12, even if said processed substrate 12 is a diameter substrate of macrostomia, or to etch said front face into homogeneity.

[0044] Drawing 4 shows the configuration of the shower plates 141-144 by various modifications of said shower plate 14.

[0045] With reference to drawing 4 , said shower plate 142 is understood that said shower plate 141 has the concave surface of a truncated-cone configuration to having the concave surface of a cone configuration in the side which meets said processed substrate 12. Furthermore on said shower plate 143, the circular crevice forms the level difference configuration, and two or more level difference configuration crevices are formed on said shower plate 144. These crevices are formed in axial symmetry by each to the medial axis of said shower plate, and uniform processing is guaranteed around said medial axis.

[2nd example] drawing 5 shows the configuration of plasma treatment equipment 10A by the 2nd example of this invention. However, the same reference mark is given to the part explained previously among drawing 5 , and explanation is omitted.

[0046] Although plasma treatment equipment 10A has said plasma treatment equipment 10 and a similar configuration with reference to drawing 5 and the spacing D of said processed substrate 12 and shower plate 14 decreases toward the method of the outside of the improvement in the method of a radius of said shower plate 14, in said plasma treatment equipment 10A, said raw gas feed zone 13 is removed.

[0047] Although raw gas cannot be supplied and neither membrane formation nor etching can be performed apart from plasma gas in plasma treatment equipment 10B of this configuration since said lower-berth shower plate 31 is omitted, it is possible by supplying oxidation gas or nitriding gas with plasma gas from said shower plate 14 to form an oxide film, a nitride, or an acid nitride in a processed substrate front face. In plasma treatment equipment 10A of this example, it is possible for a configuration to be simplified and to reduce manufacture costs greatly.

[0048] Also in this example, since said spacing D decreases in the periphery of the processed substrate 12, the fall of the plasma consistency in processed substrate 12 periphery is compensated, the plasma is maintained by stability, and problems, such as disappearance of the plasma in processed substrate 12 periphery, damage on the substrate by microwave, or a fall of processing speed, can be avoided.

[0049] In especially plasma treatment equipment 10A of drawing 5 , it is possible to be low temperature and to carry out efficiently oxidation treatment and nitriding treatment of the processed substrate 12, acid nitriding treatment, etc. to homogeneity at cheap costs, even if said processed substrate is a diameter substrate of macrostomia.

[0050] Also in this example, it is possible to use the shower plates 141-143 explained by drawing 4 instead of said shower plate 14.

[3rd example] drawing 6 shows the configuration of plasma treatment equipment 10B by the 3rd example of this invention. However, the same reference mark is given to the part corresponding to the part explained previously among drawing 6 , and explanation is omitted.

[0051] With reference to drawing 6 , sintered alumina etc. uses shower plate 14P which consist

of a porosity ceramic instead of said shower plate 14 in this example.
[0052] Although opening so that shower 14A in the shower plate 14 is not formed into said shower plate 14P, the plasma gas which the plasma gas supply ways 14C and 14B connected to plasma gas supply-port 11P are formed, and was supplied passes along the pore in said porosity shower plate 14P from said plasma gas supply way 14B, and is uniformly emitted to said space 11B.
[0053] Also in this example, said inferior surface of tongue of shower plate 14P forms a concave surface symmetrical with a shaft, and the spacing D between said inferior surfaces of tongue and front faces of the processed substrate 12 decreases toward the periphery of the processed substrate 12. For this reason, in the configuration of drawing 6 , the fall of the plasma consistency in the periphery of said processed substrate 12 is compensated, the plasma is maintained by stability, and problems, such as disappearance of the plasma in processed substrate 12 periphery, damage on the substrate by microwave, or a fall of processing speed, can be avoided.
[0054] In plasma treatment equipment 10B of drawing 6 , it is possible by introducing various oxidization gas and nitriding gas, material gas, and etching gas from said raw gas supply structure 13 to be low temperature, and to deposit various high quality film on homogeneity all over the front face of said processed substrate 12, or to etch said front face into homogeneity.
[0055] Also in this example, various concave surfaces shown in drawing 4 can be formed as said concave surface of porosity shower plate 14P.
[4th example] drawing 7 shows the configuration of plasma treatment equipment 10C by the 4th example of this invention. However, the same reference mark is given to the part explained previously among drawing 7 , and explanation is omitted.
[0056] Although plasma treatment equipment 10C of this example has the same configuration as previous plasma treatment equipment 10B with reference to drawing 7 , said lower-berth shower plate 31 is removed. Moreover, the radius of circle is formed all over said overhang section 11b holding said shower plate 14.
[0057] Although raw gas cannot be supplied and neither membrane formation nor etching can be performed apart from plasma gas in plasma treatment equipment 10C of this configuration since said lower-berth shower plate 31 is omitted, it is possible by supplying oxidation gas or nitriding gas with plasma gas from said shower plate 14 to form an oxide film, a nitride, or an acid nitride in a processed substrate front face.
[0058] Also in this example, said inferior surface of tongue of shower plate 14P forms a concave surface symmetrical with a shaft, and the spacing D between said inferior surfaces of tongue and front faces of the processed substrate 12 decreases toward the periphery of the processed substrate 12. For this reason, in the configuration of drawing 7 , the fall of the plasma consistency in the periphery of said processed substrate 12 is compensated, the plasma is maintained by stability, and problems, such as disappearance of the plasma in processed substrate 12 periphery, damage on the substrate by microwave, or a fall of processing speed, can be avoided.
[0059] In especially plasma treatment equipment 10C of drawing 7 , it is possible to be low temperature and to carry out efficiently oxidation treatment and nitriding treatment of the processed substrate 12, acid nitriding treatment, etc. to homogeneity at cheap costs, even if said processed substrate is a diameter substrate of macrostomia.
[0060] Also in shower plate 14P of this example, various concave surfaces shown in drawing 4 can be used.
[5th example] drawing 8 shows the configuration of plasma treatment equipment 10D by the 5th example of this invention. However, the same reference mark is given to the part explained previously among drawing 8 , and explanation is omitted.
[0061] With reference to drawing 8 , in an example, porosity shower plate 14P and the cover plate 15 in the example of drawing 6 are removed, and microwave transparency aperture 14Q which becomes the side which meets said processed substrate 12 instead from the precise ceramic which has a concave surface is prepared. Said microwave transparency aperture 14 can be formed with an ingredient with little dielectric loss, for example, the alumina which carried out

HIP processing.
[0062] With the configuration of drawing 8 , although said microwave transparency aperture 14Q achieves the function of said cover plate 15, opening 14A which is open for free passage to plasma gas path 14C and this in the example of drawing 6 is not formed, but the plasma gas induction which becomes the outer wall of the processing container 11 from tubing 11P is formed independently. Moreover, on said microwave transparency aperture 14Q, it is [the radial line slot antenna 20] close, and it is formed. As for said plasma gas installation tubing 11P, it is desirable to be symmetrically arranged in the perimeter of said processed substrate 12.
[0063] With this configuration, the inferior surface of tongue of said microwave transparency aperture 14Q forms a concave surface symmetrical with a shaft, and the spacing D between said inferior surfaces of tongue and front faces of the processed substrate 12 decreases toward the periphery of the processed substrate 12. For this reason, in the configuration of drawing 8 , the fall of the plasma consistency in the periphery of said processed substrate 12 is compensated, the plasma is maintained by stability, and problems, such as disappearance of the plasma in processed substrate 12 periphery, damage on the substrate by microwave, or a fall of processing speed, can be avoided.
[0064] In especially plasma treatment equipment 10D of drawing 8 , it is possible to be low temperature and to carry out efficiently oxidation treatment and nitriding treatment of the processed substrate 12, acid nitriding treatment, etc. to homogeneity at cheap costs, even if said processed substrate is a diameter substrate of macrostomia. The configuration for introducing especially plasma gas is simplified, and it contributes to reduction of costs.
[0065] Also in the plasma transparency aperture of this example, various concave surfaces shown in drawing 4 can be used.
[6th example] drawing 9 shows the configuration of plasma treatment equipment 10E by the 6th example of this invention. However, the same reference mark is given to the part explained previously among drawing 9 , and explanation is omitted.
[0066] Although plasma treatment equipment 10E of this example has previous plasma treatment equipment 10D and a similar configuration with reference to drawing 9 , said raw gas supply structure 31 is removed.
[0067] According to this configuration, it becomes possible by supplying nitriding nature gas, such as oxidizing gases, such as inert gas, such as Kr and Ar, and O2 gas, NH3 gas, or mixed gas of N2 and H2, from said plasma gas installation tubing 11P to form efficiently the oxide film, nitride, or acid nitride of high quality in the front face of said processed substrate 12 at low temperature.
[0068] Since the spacing D between the inferior surface of tongue of said microwave transparency aperture 14Q and the processed substrate 12 is decreasing in the periphery of said processed substrate 12 by this example in that case, sufficient plasma consistency is secured in said processed substrate 12 periphery, and processing of said processed substrate 12 is carried out to homogeneity.
[0069] Also in microwave aperture 14Q of this example, various concave surfaces shown in drawing 4 can be used.
[7th example] drawing 10 shows the configuration of plasma treatment equipment 10F by the 7th example of this invention. However, the same reference mark is given to the part explained previously among drawing 10 , and explanation is omitted.
[0070] With reference to drawing 10 , this examples are consisted of by dielectric window 14Q' of uniform thickness instead of said dielectric window 14Q.
[0071] In this dielectric window 14Q', a top face forms a convex corresponding to the inferior surface of tongue which forms a concave surface. So, with the plasma treatment equipment 10 of drawing 10 , radial line slot antenna 20' which has a concave surface corresponding to said convex is used instead of said flat radial line slot antenna 20. namely, slot plate 16' in which said radial line slot antenna 20' forms a concave surface -- having -- said slot plate 16 -- it is equipped through 'the late phase plate 18 with which body of antenna 17' which forms a concave surface upwards curved in between'.
[0072] Also in plasma treatment equipment 10F of this configuration, by being able to

compensate the fall of the plasma consistency in the periphery of said processed substrate 12, and supplying more various raw gas than said raw gas feed zone 31, it crosses all over the processed substrate 12, and it becomes possible to carry out uniformly various plasma treatment, such as oxidization, nitriding, acid nitriding, deposition of still more various layers, and etching, to stability.
[8th example] drawing 11 shows the configuration of plasma treatment equipment 10G by the 8th example of this invention. However, the same reference mark is given to the part explained previously among drawing 11 , and explanation is omitted.
[0073] Although plasma treatment equipment 10G of this example have the same configuration as plasma treatment equipment 10F of a previous example with reference to drawing 11 , in this example, said raw gas feed zone 31 is removed.
[0074] Also in plasma treatment equipment 10G of this configuration, the fall of the plasma consistency in the periphery of said processed substrate 12 can be compensated, it crosses all over the processed substrate 12, and it becomes possible to carry out uniform plasma treatment, such as oxidation, and nitriding, acid nitriding, to stability.
[0075] Various deformation and modification are possible for this invention in the summary of this invention which it is not limited to the above-mentioned specific example, and was indicated to the claim.
[0076]
[Effect of the Invention] According to this invention, the fall of the plasma consistency in the periphery of a processed substrate can be compensated, the plasma is maintained also in low voltage processing, and stable plasma treatment becomes possible.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] Generally especially this invention relates to microwave plasma treatment equipment with respect to plasma treatment equipment.
[0002] A plasma treatment process and plasma treatment equipment are close to 0.1 micrometers called the so-called deep submicron component in recent years or a deep subquarter micron component, or are the overly indispensable technique for manufacture of a detailed-ized semiconductor device, and manufacture of the high resolution flat-surface display containing a liquid crystal display of having the gate length not more than it.
[0003] Although the excitation method of more various plasma than before is used as plasma treatment equipment used for manufacture of a semiconductor device or a liquid crystal display, parallel monotonous mold high-frequency excitation plasma treatment equipment or inductive-coupling mold plasma treatment equipment is especially common. However, the plasma formation of plasma treatment equipment of these former is uneven, and since the field where electron density is high is limited, performing a uniform process over the whole processed substrate surface, big processing speed, i.e., throughput, has the difficult trouble. Especially this problem becomes serious when processing the substrate of a major diameter. And with the plasma treatment equipment of these former, since electron temperature is high, a damage arises in the semiconductor device formed on a processed substrate, and that the metal contamination by sputtering of a processing interior wall is large etc. has some essential problems. For this reason, it is becoming difficult to fill the severe demand to the further detailed-izing of a semiconductor device or a liquid crystal display and improvement in the further productivity with conventional plasma treatment equipment.
[0004] The microwave plasma treatment equipment using the high density plasma excited by microwave electric field on the other hand, without using a direct-current magnetic field conventionally is proposed. For example, microwave is emitted in a processing container from the plane antenna (radial line slot antenna) which has the slot of a large number arranged so that uniform microwave might be generated, and the plasma treatment equipment of a configuration of ionizing the gas in a vacuum housing by this microwave electric field, and exciting the plasma is proposed. For example, refer to the JP,9-63793,A official report. It is possible to be able to realize a high plasma consistency over the large field directly under an antenna with the microwave plasma excited by such technique, and to perform uniform plasma treatment for a short time. And with the microwave plasma formed by this technique, in order to excite the plasma by microwave, electron temperature is low, and damage metallurgy group contamination of a processed substrate can be avoided. Since the still more uniform plasma also on a large area substrate can be excited easily, it can respond also to the production process of a semiconductor device and the manufacture of a large-sized liquid crystal display using the diameter semi-conductor substrate of macrostomia easily.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Drawing 1 (A) and (B) show the configuration of the conventional microwave plasma treatment equipment 100 using this radial line slot antenna. However, it is drawing in which drawing 1 (A) shows the sectional view of microwave plasma treatment equipment 100, and drawing 1 (B) shows the configuration of a radial line slot antenna.
[0006] With reference to drawing 1 (A), microwave plasma treatment equipment 100 has the processing room 101 exhausted from two or more exhaust air ports 116, and the maintenance base 115 holding the processed substrate 114 is formed all over said processing room 101. Since uniform exhaust air of said processing room 101 is realized, space 101A is formed in the perimeter of said maintenance base 115 in the shape of a ring, it is regular intervals like, namely, said processing room 101 can be exhausted to homogeneity through said space 101A and the exhaust air port 116 by [which open said two or more exhaust air ports 116 for free passage to said space 101A] forming in axial symmetry to a processed substrate.
[0007] On said processing room 101, the tabular shower plate 103 which it became [plate] a location corresponding to the processed substrate 114 on said maintenance base 115 from the low loss dielectric, and had much openings 107 formed in it as some outer walls of said processing room 101 is formed through the seal ring 109, and the cover plate 102 which consists of a low loss dielectric still as well as the outside of said shower plate 103 is formed through another seal ring 108.
[0008] The path 104 of plasma gas is formed in the top face at said shower plate 103, and each of two or more of said openings 107 is formed so that it may be open for free passage to said plasma gas path 104. furthermore, inside said shower plate 103 The supply path 108 of the plasma gas which is open for free passage to the plasma gas supply port 105 established in the outer wall of said processing container 101 is formed. The plasma gas supplied to said plasma gas supply port 105, such as Ar and Kr Said opening 107 is supplied through said path 104 from said supply path 108, and it is substantially emitted to space 101B of said shower plate 103 directly under of said processing container 101 interior by uniform concentration from said opening 107.
[0009] On said processing container 101, further, it estranges 4-5mm from said cover plate 102, and the radial line slot antenna 110 which has the radial plane shown in drawing 1 (B) is formed in the outside of said cover plate 102. It connects with the external source of microwave (not shown) through coaxial waveguide 110A, and said radial line slot antenna 110 excites the plasma gas emitted to said space 101B by the microwave from said source of microwave. Atmospheric air is filled up with the clearance between said cover plate 102 and the radial plane of the radial line slot antenna 110.
[0010] Said radial line slot antenna 110 Flat disk-like body of antenna 110B connected to the outside waveguide of said coaxial waveguide 110A, It consists of radiation plate 110C which had slot 110b of a large number which intersect perpendicularly with much slot 110a and this which were formed in opening of said body of antenna 110B, and which show drawing 1 (B) formed. Between said body of antenna 110B, and said radiation plate 110C, late phase plate 110D which thickness becomes from a fixed dielectric plate is inserted.
[0011] In the radial line slot antenna 110 of this configuration, although the microwave to which

electric power was supplied from said coaxial waveguide 110 advances between body of antenna 110B of the shape of said disk, and radiation plate 110C with breadth to radial, wavelength is compressed by operation of said late phase plate 110D in that case. then, the wavelength of the microwave which does in this way and advances to radial — corresponding — said slots 110a and 110b — concentric circular — and the plane wave which has a circularly-polarized wave can be substantially emitted in the perpendicular direction by forming so that it may intersect perpendicularly mutually at said radiation plate 110C.
[0012] The uniform high density plasma is formed in space 101B of said shower plate 103 directly under by using this radial line slot antenna 110. Thus, the metal contamination which electron temperature is low, therefore a damage does not arise in the processed substrate 114, and originates in sputtering of the container wall of the processing container 101 does not produce the formed high density plasma.
[0013] With the plasma treatment equipment 100 of drawing 1 , further between said shower plates 103 and processed substrates 114 among said processing container 101 The structure 111 is formed. the conductor which had the nozzle 113 of a large number which supply raw gas through the raw gas path 112 formed into said processing container 101 from the external source of raw gas (not shown) formed — the raw gas with which each of said nozzle 113 was supplied — said conductor — it emits to space 101C between the structure 111 and the processed substrate 114. said conductor — opening of magnitude which passes efficiently the plasma formed in said space 101B among said adjoining nozzles 113 and 113 by diffusion from said space 101B to said space 101C is formed in the structure 111.
[0014] then — such — said conductor — when raw gas is emitted to said space 101C through said nozzle 113 from the structure 111, the emitted raw gas is excited by the high density plasma formed in said space 101B, and it is performed, without [without uniform plasma treatment moreover makes efficient and a high speed damage the component structure on a substrate and a substrate on said processed substrate 114, and] polluting a substrate. the microwave emitted from said radial line slot antenna 110 on the other hand — this conductor — it is prevented with the structure 111 and the processed substrate 114 is not damaged

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[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] According to this invention, the fall of the plasma consistency in the periphery of a processed substrate can be compensated, the plasma is maintained also in low voltage processing, and stable plasma treatment becomes possible.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] by the way, with the conventional plasma treatment equipment 100 of drawing 1 (A) and (B) Since spacing between said shower plates 103 and processed substrates 114 is narrow, Although very uniform plasma treatment becomes possible even if the continuous and stable plasma style to the direction of a path of the shower plate 103 is formed in said space 101B and 101C and said processed substrate 114 is a diameter substrate of macrostomia On the other hand, when the pressure in said processing container 101 declines, the problem to which a plasma consistency tends to fall especially in the periphery of the shower plate 103 arises. For example, when the pressure in the processing container 101 falls to 300 or less mTorrs in Ar ambient atmosphere, in the periphery of the shower plate 103, a plasma consistency falls greatly. Diffusion of the dissociated electron is promoted and this is considered to originate in disappearing by the internal surface of the processing container 101, when the pressure in the processing container 101 declines. When it falls below to the cut-off consistency which requires a plasma consistency, it becomes impossible to maintain the plasma, since the cut-off consistency of the plasma is 7.5x1010cm-3. Microwave will be directly impressed to the processed substrate 114, and the fall of the plasma consistency in this shower plate 103 periphery not only causes the fall of processing speed, but produces the problem which carries out induction of the damage.
[0016] Then, this invention makes it a general technical problem to offer the new and useful plasma treatment equipment which solved the conventional technical problem.
[0017] The more concrete technical problem of this invention is to offer the plasma treatment equipment in which uniform processing is possible over the whole processed substrate front face also in low processing pressure.

[Translation done.]

MEANS

[Means for Solving the Problem] The processing container equipped with the maintenance base which this invention is formed with an outer wall as the above-mentioned technical problem was indicated to claim 1, and holds a processed substrate, So that the processed substrate on said maintenance base may be met on said processing container with the exhaust air system combined with said processing container The microwave transparency aperture prepared as said some of outer walls, and the plasma gas feed zone which supplies plasma gas into said processing container, It consists of a microwave antenna formed on said processing container corresponding to said microwave. Said microwave transparency aperture With the plasma treatment equipment with which the inside of the side which meets said processed substrate is characterized by having the concave surface configuration in which spacing between the flat surfaces which are in agreement with said processed substrate front face decreases toward the direction outside of a path of said microwave transparency aperture As indicated to claim 2, or said spacing As indicated to the plasma treatment equipment according to claim 1 characterized by decreasing continuously toward the direction outside of a path of said microwave transparency aperture, or claim 3, said spacing As indicated to the plasma treatment equipment according to claim 2 characterized by decreasing smoothly toward the direction outside of a path of said microwave transparency aperture, or claim 4, said spacing As indicated to the plasma treatment equipment according to claim 2 or 3 characterized by decreasing linearly toward the direction outside of a path of said microwave transparency aperture, or claim 5, said spacing With the plasma treatment equipment according to claim 2 or 3 characterized by decreasing in nonlinear toward the direction outside of a path of said microwave transparency aperture As indicated to claim 6, or said spacing As indicated to the plasma treatment equipment according to claim 1 characterized by decreasing stair-like toward the direction outside of a path of said microwave transparency aperture, or claim 7, said spacing With the plasma treatment equipment according to claim 1 characterized by decreasing toward the direction outside of a path of said microwave transparency aperture only in the periphery of said microwave transparency aperture As indicated to claim 8, or said microwave transparency aperture With plasma treatment equipment given in any 1 term among claims 1-7 characterized by the external surface which counters said inside consisting of a flat side As indicated to claim 9, or said microwave transparency aperture With plasma treatment equipment given in any 1 term among claims 1-8 characterized by constituting said plasma gas feed zone which has a plasma gas path inside and emits plasma gas into said processing container As indicated to claim 10, or said microwave transparency aperture As indicated to the plasma treatment equipment according to claim 9 characterized by having two or more openings which are open for free passage to said plasma gas path, or claim 11, a microwave transparency aperture It is close to the cover plate which constitutes some outer walls of said processing container, and said cover plate, and is prepared. With the plasma treatment equipment according to claim 9 characterized by consisting of a shower plate which has two or more openings which are open for free passage to said plasma gas path and this As indicated to claim 12, with or the plasma treatment equipment according to claim 8 or 11 characterized by said microwave transparency aperture consisting of a precise ceramic As indicated to claim 13, or said microwave transparency aperture As indicated to the

plasma treatment equipment according to claim 9 characterized by consisting of porous media, or claim 14, said microwave transparency aperture With the plasma treatment equipment according to claim 9 characterized by consisting of a cover plate which constitutes said some of processing containers, and a shower plate which consists of porous media formed by being close to said cover plate As indicated to claim 15, or said porous media As indicated to the plasma treatment equipment according to claim 13 or 14 characterized by consisting of a sintering ceramic, or claim 16, said plasma gas feed zone With plasma treatment equipment given in any 1 term among claims 1-8 characterized by consisting of tubing connectable with the source of plasma gas formed in said processing container outer wall As indicated to claim 17, or said microwave transparency aperture With the plasma treatment equipment according to claim 16 characterized by consisting of a precise ceramic As indicated to claim 18, further or between said processed substrates and said sources of plasma gas As indicated to plasma treatment equipment given in any 1 term, or claim 19 among claims 1-17 characterized by preparing a raw gas feed zone, said raw gas feed zone With the plasma treatment equipment according to claim 18 characterized by having the plasma path which passes the plasma, a raw gas path connectable with the source of raw gas, and nozzle opening of a large number which were open for free passage to said raw gas path With or plasma treatment equipment given in any 1 term among claims 1-19 characterized by including the RF generator further connected to said maintenance base as indicated to claim 20 Or as indicated to claim 21, said microwave antenna is solved with plasma treatment equipment given in any 1 term among claims 1-20 characterized by consisting of a radial line slot antenna.

[Translation done.]

OPERATION

According to [operation] this invention, by forming a concave surface in the side which meets the processed substrate of said shower plate, spacing between the shower plate inferior surfaces of tongue and processed substrate front faces in which the high density plasma is formed in a processed substrate periphery decreases, and the fall of the plasma consistency in a shower plate periphery is compensated. Consequently, also when low-pressure plasma treatment, such as etching, is performed, the stable and uniform plasma is maintained [near the processed substrate front face]. Moreover, ignition of the plasma is also promoted by this configuration. Stabilization of the plasma by this concave surface formation is applicable also to the configuration which omitted not only a configuration but the raw gas feed zone which prepared the raw gas feed zone between a processed substrate and a plasma gas feed zone.
[0019] Although it is possible to use the precise ceramic member which had opening of a large number which were open for free passage to a plasma gas path and this formed as a shower plate which has this concave surface, it is also possible to use a porosity ceramic member instead of said precise ceramic member. Although these shower plates are close to the precise cover plate which constitutes a nothing plasma transparency aperture and some processing container outer walls are established, it is also possible to form said crevice in the microwave transparency aperture itself further in this invention, and to introduce plasma gas all over said processing room with tubing etc. separately, without using a shower plate.
[0020] Since cooling of the shower plate which adhesion with a microwave antenna could secure easily that the external surface which counters the inside which makes said concave surface by the shower plate or microwave transparency aperture by this invention was a flat side, and minded the antenna is attained, it is advantageous.
[0021]
[Embodiment of the Invention]

[Translation done.]

* NOTICES *

EXAMPLE

[1st example] drawing 2 (A) and (B) show the configuration of the microwave plasma treatment equipment 10 by the 1st example of this invention.
[0022] With reference to drawing 2 (A), said microwave plasma treatment equipment 10 The processing container 11, It is prepared in said processing container 11, and the maintenance base 13 which consists of AlN or aluminum 2O3 which holds the processed substrate 12 by the electrostatic chuck, and which was preferably formed of the isotropic pressure inflatable flexible bag technique (HIP) between heat is included. In said processing container 11, at least two exhaust air port 11a is preferably formed by **** symmetric relation at three or more places at space 11A surrounding said maintenance base 13 to the processed substrate 12 on regular intervals 13, i.e., said maintenance base. Said processing container 11 minds this exhaust air port 11a, and is exhausted and decompressed by an irregular-pitch inequality inclination screw pump etc.
[0023] Said processing container 11 consists of an austenitic stainless steel which contains aluminum preferably, and the protective coat which consists of an aluminum oxide by oxidation treatment is formed in the internal surface. Moreover, the shower plate 14 of the shape of a disk which it consisted [shape] of precise aluminum 2O3 formed by the HIP method, and had much nozzle opening 14A formed is formed in the part corresponding to said processed substrate 12 as said some of outer walls among the outer walls of said processing container 11. 14 is formed using the aluminum2O3 shower plateY2O3 formed by this HIP method as sintering acid, and has the very big thermal conductivity as a ceramic to which porosity reaches 30 W/m-K excluding pore or a pinhole substantially at 0.03% or less.
[0024] It is equipped with said shower plate 14 through seal ring 11s on said processing container 11, and the cover plate 15 which consists of precise aluminum 2O3 further formed of the same HIP processing on said shower plate 14 is formed through seal ring 11t. Crevice 14B which is open for free passage at each of said nozzle opening 14A to the side which touches said cover plate 15 of said shower plate 14, and becomes plasma gas passage is formed, and said crevice 14B is open for free passage to another plasma gas passage 14C which is open for free passage to plasma gas inlet-port 11p which was formed in the interior of said shower plate 14, and was formed in the outer wall of said processing container 11.
[0025] In order that said shower plate 14 may control abnormality discharge into the part which was formed in the wall of said processing container 11 and which ******s, is held by section 11b and holds said shower plate 14 among said overhang section 11b, the radius of circle is formed.
[0026] Then, after the plasma gas supplied to said plasma gas inlet-port 11p, such as Ar and Kr, carries out sequential passage of the passage 14C and 14B of said shower plate 14 interior, it is uniformly supplied into space 11B of said shower plate 14 directly under through said opening 14A.
[0027] The slot plate 16 of the shape of a disk which had many slots 16a and 16b which are close to said cover plate 15, and are shown in drawing 3 (B) formed on said cover plate 15, The body 17 of an antenna of the shape of a disk holding said slot plate 16, The radial line slot antenna 20 constituted with the late phase plate 18 which consists of low loss dielectric materials of aluminum [which was pinched between said slot plates 16 and said bodies 17 of an

antenna] 2O3, Si3N4, SiON, or SiO2 grade is formed. It is equipped with said radial slot line antenna 20 through seal ring 11u on said processing container 11, and the microwave whose frequency is 2.45GHz or 8.3GHz is supplied to said radial line slot antenna 20 from the external source of microwave (not shown) through the coaxial waveguide 21 which has a rectangle or a circular cross section. The supplied microwave is emitted into said processing container 11 through said cover plate 15 and the shower plate 14 from the slots 16a and 16b on said slot plate 16, and excites the plasma in space 11B of said shower plate 14 directly under in the plasma gas supplied from said opening 14A from it. In that case, said cover plate 15 and the shower plate 14 are formed of aluminum 2O3, and act as an efficient microwave transparency aperture. In order to avoid that the plasma is excited in said plasma gas passage 14A-14C in that case, said plasma gas is held in said passage 14A-14C at the pressure of about 6666Pa - 13332Pa (about 50 to 100 Torr).

[0028] In order to raise the adhesion of said radial line slot antenna 20 and said cover plate 15, 11g of ring-like slots is formed in a part of top face of said processing container 11 which engages with said slot plate 16 with the microwave plasma treatment equipment 10 of this example. By exhausting 11g of these slots through exhaust air port 11G which were open for free passage to this The clearance formed between said slot plates 16 and cover plates 15 is decompressed, and an atmospheric pressure enables it to push said radial line slot antenna 20 against said cover plate 15 firmly. Although the slots 16a and 16b formed in said slot plate 16 are included, a clearance may be formed in this clearance of various reasons of irregularity with cover-plate 15 detailed front face etc. besides it. The closure of this clearance is carried out by seal ring 11u between said radial line slot antennas 20 and processing containers 11.

[0029] By furthermore filling up the clearance between said slot plates 16 and said cover plates 15 with inert gas with small molecular weight through said exhaust air port 11G and 15g of slots, transportation of the heat from said cover plate 15 to said slot plate 16 can be promoted. As this inert gas, it is desirable that thermal conductivity, large moreover, uses high helium of ionization energy. When filling up said clearance with helium, it is desirable to set it as the pressure of 0.8 atmospheric-pressure extent. With the configuration of drawing 3 , bulb 11V are connected to said exhaust air port 11G for exhaust air of 15g of said slots, and restoration of 15g [of slots] inert gas.

[0030] Outside waveguide 21A is connected to the body 17 of an antenna of the shape of said disk among said coaxial waveguide 21A, and central conductor 21B is connected to said slot plate 16 through opening formed in said slow wave plate 18. Then, the microwave supplied to said coaxial waveguide 21A is emitted from said slots 16a and 16b, going on between said bodies 17 of an antenna and slot plates 16 in the direction of a path.

[0031] Drawing 2 (B) shows the slots 16a and 16b formed on said slot plate 16.

[0032] With reference to drawing 2 (B), said slot 16a is arranged by concentric circular, and, similarly slot 16b which goes to this direct is formed in concentric circular corresponding to each slot 16a. Said slots 16a and 16b are formed at spacing corresponding to the wavelength of the microwave compressed into radial [of said slot plate 16] with said late phase plate 18, and as a result, microwave turns into an approximate plane wave from said slot plate 16, and is emitted. Since said slots 16a and 16b are formed by the relation relation and mutual cross at right angles in that case, the microwave emitted by doing in this way forms the circularly-polarized wave containing two polarization components which intersect perpendicularly.

[0033] With the plasma treatment equipment 10 of this example, the front face of the side which meets said processed substrate 12 of said shower plate 14 forms the curve side of a concave surface configuration, and the spacing D between the flat surfaces which are in agreement with the front face of said shower plate 14 and processed substrate 12 as a result decreases smoothly toward the method of the outside of the improvement in the method of a radius of said shower plate 14. That is, said concave surface configuration is formed by the curved surface symmetrical with a shaft, and in order that said spacing D may decrease in the periphery of said processed substrate 12, the problem of a fall of the plasma consistency in this processed substrate periphery is solved.

[0034] Thereby, with said plasma treatment equipment 10, even if it performs plasma treatment

with the need of carrying out by hypobaric environment-ization, such as dry etching, a plasma consistency does not fall below to a cut-off consistency, and the plasma is maintained by stability and can avoid problems, such as disappearance of the plasma in processed substrate 12 periphery, damage on the substrate by microwave, or a fall of processing speed.

[0035] Furthermore with the plasma treatment equipment 10 of drawing 2 (A), the cooling block 19 which had cooling water path 19A formed is formed on said body 17 of an antenna, and the heat accumulated in said shower plate 14 is absorbed through said radial line slot antenna 20 by cooling said cooling block 19 with the cooling water in said cooling water path 19A. It lets the cooling water which said cooling water path 19A is formed in the shape of a spiral on said cooling block 19, and eliminated dissolved oxygen by carrying out bubbling of the H2 gas preferably, and controlled the oxidation reduction potential pass.

[0036] moreover, with the microwave plasma treatment equipment 10 of drawing 2 (A) Among said processing container 11 between said shower plates 14 and processed substrates 12 on said maintenance base 13 The raw gas supply structure 31 of having raw gas path 31A of the shape of a grid which raw gas is supplied from raw gas inlet 11r prepared in the outer wall of said processing container 11, and emits this from much raw gas nozzle orifice section 31B (refer to drawing 3) is established. Desired uniform substrate processing is made in space 11C between said raw gas supply structures 31 and said processed substrates 12. Plasma oxidation processing, plasma nitriding treatment, plasma acid nitriding treatment, plasma-CVD processing, etc. are included in this substrate processing. Moreover, it is possible to perform reactive ion etching to said processed substrate 12 by supplying etching gas, such as fluorocarbon gas which is [6 / C4F8, C5F8, / C4F] easy to dissociate, and F system or Cl system, from said raw gas supply structure 31 to said space 11C, and impressing high-frequency voltage to said maintenance base 13 from RF generator 13A.

[0037] with the microwave plasma treatment equipment 10 by this example, adhesion of a reaction by-product etc. in a processing container wall avoids the outer wall of said processing container 11 by heating to 150-degree about C temperature — having — a day — about 1 time of dry-cleaning **** — it is things and stabilizing and operating is possible regularly.

[0038] Drawing 4 is the bottom view showing the configuration of the raw gas supply structure 31 in the configuration of drawing 2 (A).

[0039] With reference to drawing 4 , it consists of conductors containing Mg, such as aluminum alloy and aluminum addition stainless steel, and said grid-like raw gas path 31A is connected to said raw gas inlet 11r in raw gas supply-port 31R, and said raw gas supply structure 31 emits raw gas to homogeneity at said space 11C from raw gas nozzle orifice section 31B of a large number by which inferior-surface-of-tongue formation was carried out. Moreover, opening 31C which passes the raw gas contained in the plasma or the plasma is formed between raw gas path 31A which adjoins said raw gas supply structure 31. When forming said raw gas supply structure 31 with a Mg content aluminum alloy, it is desirable to form the fluoride film in a front face. Moreover, when forming said raw gas supply structure 31 by aluminum addition stainless steel, it is desirable to form the passive state film of an aluminum oxide in a front face. With the plasma treatment equipment 10 by this invention, since the electron temperature in the plasma which is excited and which is excited is low, the incidence energy of the plasma is small, and the problem which sputtering of this raw gas supply structure 31 is carried out, and metal contamination produces in the processed substrate 12 is avoided. Said raw gas supply structure 31 can also be formed with ceramics, such as an alumina.

[0040] Said grid-like raw gas path 31A and raw gas nozzle orifice section 31B are prepared so that a little larger field than the processed substrate 12 shown in drawing 4 with the broken line may be covered. By establishing this raw gas supply structure 31 between said shower plates 14 and processed substrates 12, plasma excitation of the raw gas, such as material gas and etching gas, is carried out, and this raw gas by which plasma excitation was carried out enables it to process to homogeneity.

[0041] In forming said raw gas supply structure 31 with conductors, such as a metal, said raw gas supply structure 31 forms the short circuit side of microwave by setting up shorter than the wavelength of said microwave said spacing between grid-like raw gas path 31A. In this case, the

microwave excitation of the plasma is produced in said space 11B, and raw gas is activated by the plasma diffused from said excitation space 11B in space 11C including the front face of said processed substrate 12.
[0042] Since supply of raw gas is uniformly controlled by the microwave plasma treatment equipment 10 by this example by using the raw gas supply structure 31, even when the problem of superfluous dissociation in processed substrate 12 front face of raw gas can be solved and the large structure of an aspect ratio is formed in the front face of the processed substrate 12, it is possible to carry out desired substrate processing even in the inner part of this high aspect structure. That is, microwave plasma treatment equipment 10 is effective in manufacture of many generations' semiconductor device with which the design Ruhr differs.
[0043] In plasma treatment equipment 10B of drawing 5 , it is possible by introducing various oxidization gas and nitriding gas, material gas, and etching gas from said raw gas supply structure 13 to be low temperature, to deposit various high quality film on homogeneity all over the front face of said processed substrate 12, even if said processed substrate 12 is a diameter substrate of macrostomia, or to etch said front face into homogeneity.
[0044] Drawing 4 shows the configuration of the shower plates 141-144 by various modifications of said shower plate 14.
[0045] With reference to drawing 4 , said shower plate 142 is understood that said shower plate 141 has the concave surface of a truncated-cone configuration to having the concave surface of a cone configuration in the side which meets said processed substrate 12. Furthermore on said shower plate 143, the circular crevice forms the level difference configuration, and two or more level difference configuration crevices are formed on said shower plate 144. These crevices are formed in axial symmetry by each to the medial axis of said shower plate, and uniform processing is guaranteed around said medial axis.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (A) and (B) are drawings showing the configuration of the microwave plasma treatment equipment using the conventional radial line slot antenna.
[Drawing 2] (A) and (B) are drawings showing the configuration of the plasma treatment equipment by the 1st example of this invention.
[Drawing 3] It is the bottom view showing the configuration of the raw gas supply structure used with the plasma treatment equipment of drawing 2 (A) and (B).
[Drawing 4] It is drawing showing various modifications of the plasma treatment equipment of drawing 2 (A) and (B).
[Drawing 5] It is drawing showing the configuration of the plasma treatment equipment by the 2nd example of this invention.
[Drawing 6] It is drawing showing the configuration of the plasma treatment equipment by the 3rd example of this invention.
[Drawing 7] It is drawing showing the configuration of the plasma treatment equipment by the 4th example of this invention.
[Drawing 8] It is drawing showing the configuration of the plasma treatment equipment by the 5th example of this invention.
[Drawing 9] It is drawing showing the configuration of the plasma treatment equipment by the 6th example of this invention.
[Drawing 10] It is drawing showing the configuration of the plasma treatment equipment by the 7th example of this invention.
[Drawing 11] It is drawing showing the configuration of the plasma treatment equipment by the 8th example of this invention.
[Description of Notations]
10 and 10A- 10G and 100 Plasma treatment equipment
11 Processing Container
11a Exhaust air port
11b Overhang section
11p Plasma gas supply port
11r Raw gas supply port
11A, 11B, 11C Space
11G Reduced pressure and helium supply port
11P Plasma gas inlet
12 Processed Substrate
13 Maintenance Base
13A RF generator
14 Shower Plate
14P Porosity shower plate
14A Plasma gas-nozzle opening
14B, 14C Plasma gas path
14Q, 14Q' Microwave transparency aperture

15 Cover Plate
16 16' Slot plate
16a, 16b Slot opening
17 17' Body of an antenna
18 18' Slow wave plate
18A, 18B Ring-like member
19 Cooling Block
19A Cooling water path
20 20' Radial line antenna
21 Coaxial Waveguide
21A Outside waveguide
21B Inside feeder
31 Raw Gas Supply Structure
31A Raw gas path
31B Processing gas nozzle
31C Plasma diffusion path
31R Raw gas supply port

[Translation done.]

* NOTICES *

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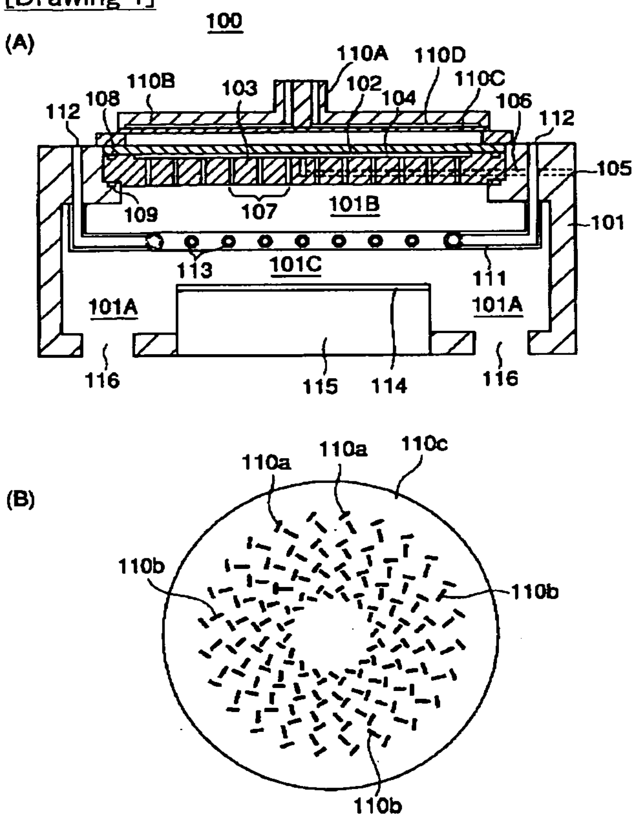
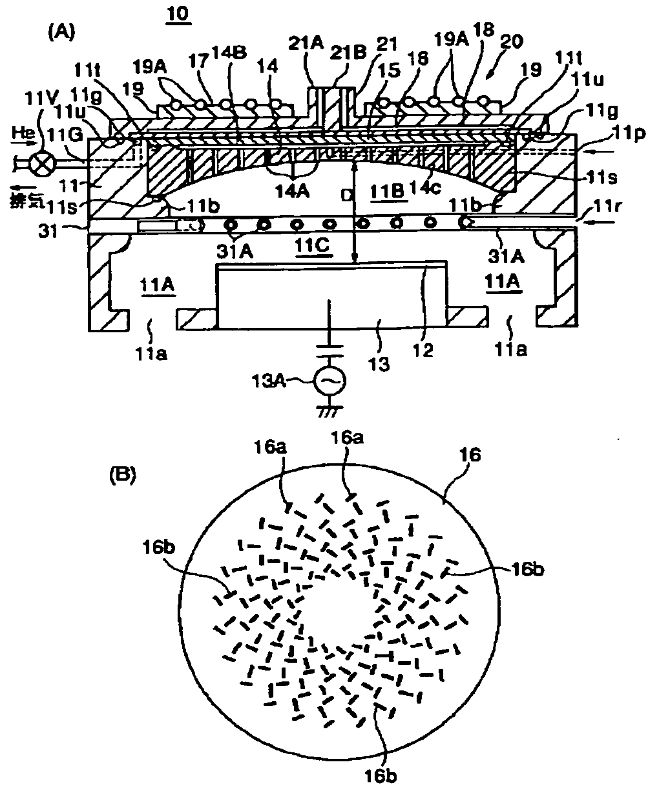
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

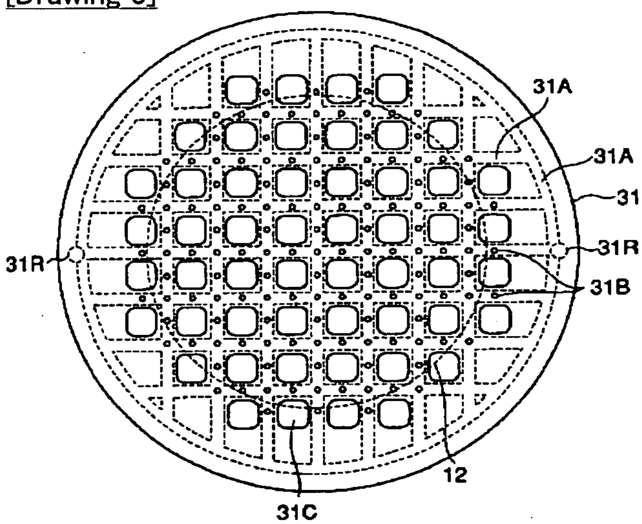
[Drawing 1]



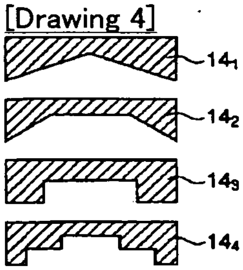
[Drawing 2]



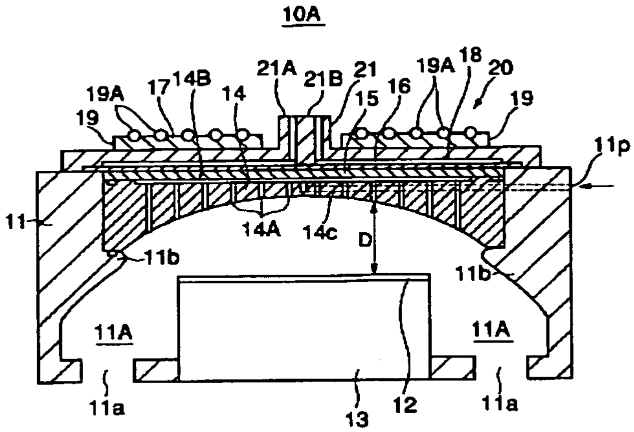
[Drawing 3]



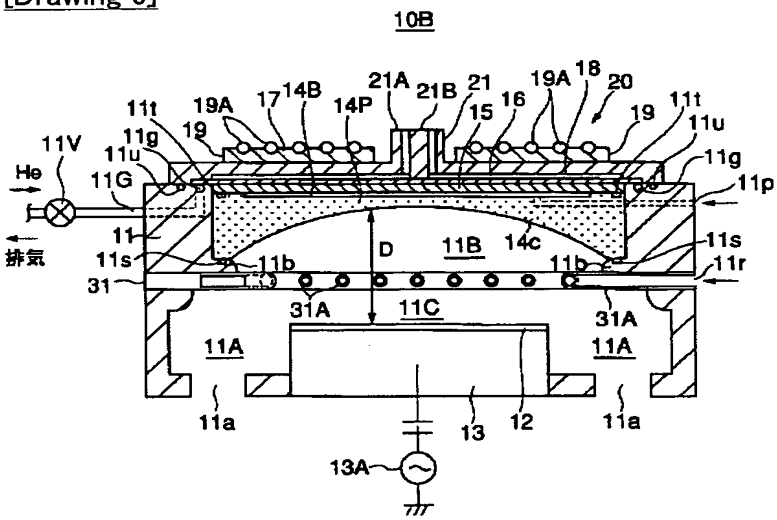
[Drawing 4]



[Drawing 5]



[Drawing 6]



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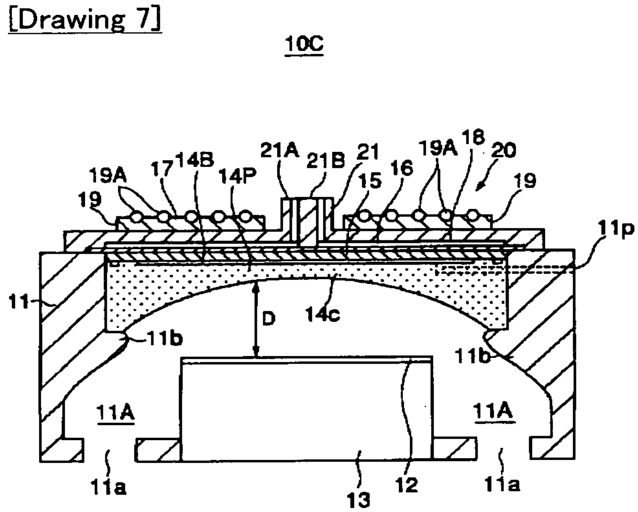
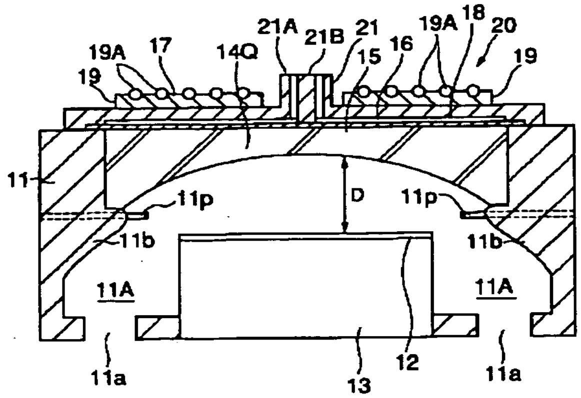


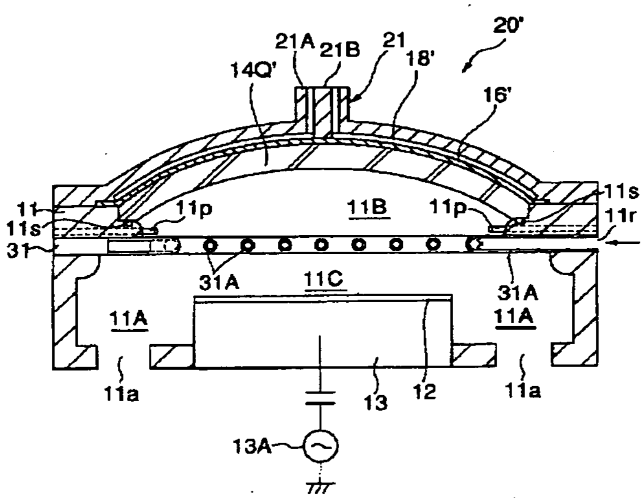
[Drawing 9]

10E



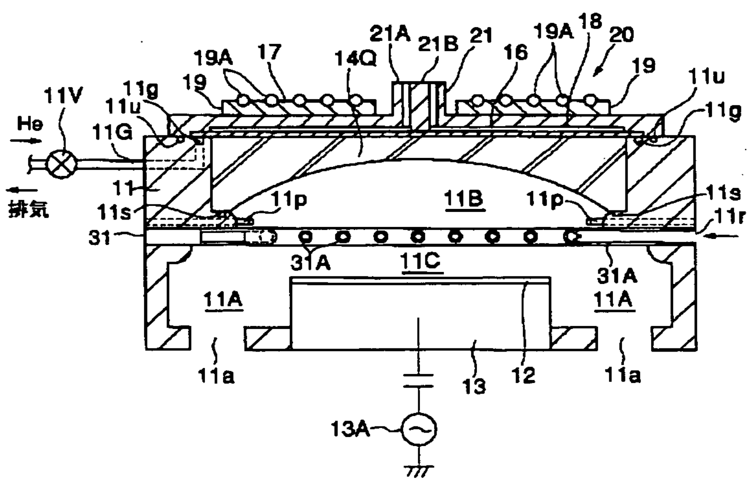
[Drawing 10]

10F



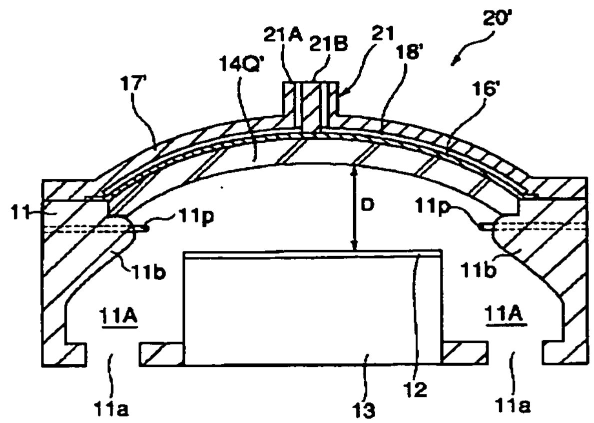
[Drawing 8]

10D



[Drawing 11]

10G



[Translation done.]

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Ｈ０１Ｌ　21/3065		Ｈ０５Ｈ　1/46　Ｂ	５Ｆ０４５
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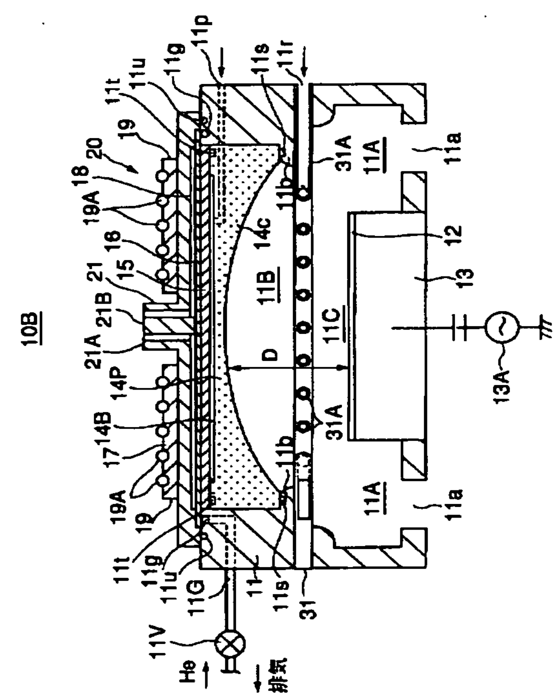
(54)【発明の名称】　プラズマ処理装置

(57)【要約】
【課題】　マイクロ波プラズマ処理装置において、被処理基板周辺部でのプラズマ密度の低下を補償する。
【解決手段】　被処理基板に対面するシャワープレートあるいはプラズマ透過窓の、前記被処理基板に対面する側を凹面形状とする。



【特許請求の範囲】

【請求項１】　外壁により画成され、被処理基板を保持する保持台を備えた処理容器と、
前記処理容器に結合された排気系と、
前記処理容器上に、前記保持台上の被処理基板に対面するように、前記外壁の一部として設けられたマイクロ波透過窓と、
前記処理容器中にプラズマガスを供給するプラズマガス供給部と、
前記処理容器上に、前記マイクロ波に対応して設けられたマイクロ波アンテナとよりなり、
前記マイクロ波透過窓は、前記被処理基板と対面する側の内面が、前記被処理基板表面に一致する平面との間の間隔が、前記マイクロ波透過窓の径方向外側に向って減少する凹面形状を有することを特徴とするプラズマ処理装置。

【請求項２】　前記間隔は、前記マイクロ波透過窓の径方向外側に向って連続的に減少することを特徴とする請求項１記載のプラズマ処理装置。

【請求項３】　前記間隔は、前記マイクロ波透過窓の径方向外側に向って滑らかに減少することを特徴とする請求項２記載のプラズマ処理装置。

【請求項４】　前記間隔は、前記マイクロ波透過窓の径方向外側に向って直線的に減少することを特徴とする請求項２または３記載のプラズマ処理装置。

【請求項５】　前記間隔は、前記マイクロ波透過窓の径方向外側に向って非直線的に減少することを特徴とする請求項２または３記載のプラズマ処理装置。

【請求項６】　前記間隔は、前記マイクロ波透過窓の径方向外側に向って階段状に減少することを特徴とする請求項１記載のプラズマ処理装置。

【請求項７】　前記間隔は、前記マイクロ波透過窓の周辺部においてのみ、前記マイクロ波透過窓の径方向外側に向って減少することを特徴とする請求項１記載のプラズマ処理装置。

【請求項８】　前記マイクロ波透過窓は、前記内面に対向する外面が、平坦面よりなることを特徴とする請求項１～７のうち、いずれか一項記載のプラズマ処理装置。

【請求項９】　前記マイクロ波透過窓は、内部にプラズマガス通路を有し、前記処理容器中にプラズマガスを放出する前記プラズマガス供給部を構成することを特徴とする請求項１～８のうち、いずれか一項記載のプラズマ処理装置。

【請求項１０】　前記マイクロ波透過窓は、前記プラズマガス通路に連通する複数の開口部を有することを特徴とする請求項９記載のプラズマ処理装置。

【請求項１１】　マイクロ波透過窓は、前記処理容器の外壁の一部を構成するカバープレートと、前記カバープレートに密接して設けられ、前記プラズマガス通路とこれに連通する複数の開口部とを有するシャワープレートよりなることを特徴とする請求項１０記載のプラズマ処理装置。

【請求項１２】　前記マイクロ波透過窓は緻密なセラミックよりなることを特徴とする請求項１０または１１記載のプラズマ処理装置。

【請求項１３】　前記マイクロ波透過窓は、多孔質媒体より構成されることを特徴とする請求項９記載のプラズマ処理装置。

【請求項１４】　前記マイクロ波透過窓は、前記処理容器の一部を構成するカバープレートと、前記カバープレートに密接して設けられた多孔質媒体よりなるシャワープレートとよりなることを特徴とする請求項９記載のプラズマ処理装置。

【請求項１５】　前記多孔質媒体は、焼結セラミックよりなることを特徴とする請求項１３または１４記載のプラズマ処理装置。

【請求項１６】　前記プラズマガス供給部は、前記処理容器外壁に形成された、プラズマガス源に接続可能な管よりなることを特徴とする請求項１～８のうち、いずれか一項記載のプラズマ処理装置。

【請求項１７】　前記マイクロ波透過窓は、緻密なセラミックよりなることを特徴とする請求項１６記載のプラズマ処理装置。

【請求項１８】　さらに、前記被処理基板と前記プラズマガス源との間に、処理ガス供給部を設けたことを特徴とする請求項１～１７のうち、いずれか一項記載のプラズマ処理装置。

【請求項１９】　前記処理ガス供給部は、プラズマを通過させるプラズマ通路と、処理ガス源に接続可能な処理ガス通路と、前記処理ガス通路に連通した多数のノズル開口部とを有することを特徴とする請求項１８記載のプラズマ処理装置。

【請求項２０】　さらに前記保持台に接続された高周波電源を含むことを特徴とする請求項１～１９のうち、いずれか一項記載のプラズマ処理装置。

【請求項２１】　前記マイクロ波アンテナはラジアルラインスロットアンテナよりなることを特徴とする請求項１～２０のうち、いずれか一項記載のプラズマ処理装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は一般にプラズマ処理装置に係わり、特にマイクロ波プラズマ処理装置に関する。

【０００２】プラズマ処理工程およびプラズマ処理装置は、近年のいわゆるディープサブミクロン素子あるいはディープサブクォーターミクロン素子と呼ばれる０．１μｍに近い、あるいはそれ以下のゲート長を有する超微細化半導体装置の製造や、液晶表示装置を含む高解像度平面表示装置の製造にとって、不可欠の技術である。

【０００３】半導体装置や液晶表示装置の製造に使われるプラズマ処理装置としては、従来より様々なプラズマの励起方式が使われているが、特に平行平板型高周波励起プラズマ処理装置あるいは誘導結合型プラズマ処理装置が一般的である。しかしこれら従来のプラズマ処理装置は、プラズマ形成が不均一であり、電子密度の高い領域が限定されているため大きな処理速度すなわちスループットで被処理基板全面にわたり均一なプロセスを行うのが困難である問題点を有している。この問題は、特に大径の基板を処理する場合に深刻になる。しかもこれら従来のプラズマ処理装置では、電子温度が高いため被処理基板上に形成される半導体素子にダメージが生じ、また処理室壁のスパッタリングによる金属汚染が大きいなど、いくつかの本質的な問題を有している。このため、従来のプラズマ処理装置では、半導体装置や液晶表示装置のさらなる微細化およびさらなる生産性の向上に対する厳しい要求を満たすことが困難になりつつある。

【０００４】一方、従来より直流磁場を用いずにマイクロ波電界により励起された高密度プラズマを使うマイクロ波プラズマ処理装置が提案されている。例えば、均一なマイクロ波を発生するように配列された多数のスロットを有する平面状のアンテナ（ラジアルラインスロットアンテナ）から処理容器内にマイクロ波を放射し、このマイクロ波電界により真空容器内のガスを電離してプラズマを励起させる構成のプラズマ処理装置が提案されている。例えば特開平９－６３７９３公報を参照。このような手法で励起されたマイクロ波プラズマではアンテナ直下の広い領域にわたって高いプラズマ密度を実現でき、短時間で均一なプラズマ処理を行うことが可能である。しかもかかる手法で形成されたマイクロ波プラズマではマイクロ波によりプラズマを励起するため電子温度が低く、被処理基板のダメージや金属汚染を回避することができる。さらに大面積基板上にも均一なプラズマを容易に励起できるため、大口径半導体基板を使った半導体装置の製造工程や大型液晶表示装置の製造にも容易に対応できる。

【０００５】

【従来の技術】図１（Ａ），（Ｂ）は、かかるラジアルラインスロットアンテナを使った従来のマイクロ波プラズマ処理装置１００の構成を示す。ただし図１（Ａ）はマイクロ波プラズマ処理装置１００の断面図を、また図１（Ｂ）はラジアルラインスロットアンテナの構成を示す図である。

【０００６】図１（Ａ）を参照するに、マイクロ波プラズマ処理装置１００は複数の排気ポート１１６から排気される処理室１０１を有し、前記処理室１０１中には被処理基板１１４を保持する保持台１１５が形成されている。前記処理室１０１の均一な排気を実現するため、前記保持台１１５の周囲にはリング状に空間１０１Ａが形成されており、前記複数の排気ポート１１６を前記空間１０１Ａに連通するように等間隔で、すなわち被処理基板に対して軸対称に形成することにより、前記処理室１０１を前記空間１０１Ａおよび排気ポート１１６を介して均一に排気することができる。

【０００７】前記処理室１０１上には、前記保持台１１５上の被処理基板１１４に対応する位置に、前記処理室１０１の外壁の一部として、低損失誘電体よりなり多数の開口部１０７を形成された板状のシャワープレート１０３がシールリング１０９を介して形成されており、さらに前記シャワープレート１０３の外側に同じく低損失誘電体よりなるカバープレート１０２が、別のシールリング１０８を介して設けられている。

【０００８】前記シャワープレート１０３にはその上面にプラズマガスの通路１０４が形成されており、前記複数の開口部１０７の各々は前記プラズマガス通路１０４に連通するように形成されている。さらに、前記シャワープレート１０３の内部には、前記処理容器１０１の外壁に設けられたプラズマガス供給ポート１０５に連通するプラズマガスの供給通路１０８が形成されており、前記プラズマガス供給ポート１０５に供給されたＡｒやＫｒ等のプラズマガスは、前記供給通路１０８から前記通路１０４を介して前記開口部１０７に供給され、前記開口部１０７から前記処理容器１０１内部の前記シャワープレート１０３直下の空間１０１Ｂに、実質的に一様な濃度で放出される。

【０００９】前記処理容器１０１上には、さらに前記カバープレート１０２の外側に、前記カバープレート１０２から４～５ｍｍ離間して、図１（Ｂ）に示す放射面を有するラジアルラインスロットアンテナ１１０が設けられている。前記ラジアルラインスロットアンテナ１１０は外部のマイクロ波源（図示せず）に同軸導波管１１０Ａを介して接続されており、前記マイクロ波源からのマイクロ波により、前記空間１０１Ｂに放出されたプラズマガスを励起する。前記カバープレート１０２とラジアルラインスロットアンテナ１１０の放射面との間の隙間は大気により充填されている。

【００１０】前記ラジアルラインスロットアンテナ１１０は、前記同軸導波管１１０Ａの外側導波管に接続された平坦なディスク状のアンテナ本体１１０Ｂと、前記アンテナ本体１１０Ｂの開口部に形成された、図１（Ｂ）に示す多数のスロット１１０ａおよびこれに直交する多数のスロット１１０ｂを形成された放射板１１０Ｃとよりなり、前記アンテナ本体１１０Ｂと前記放射板１１０Ｃとの間には、厚さが一定の誘電体板よりなる遅相板１１０Ｄが挿入されている。

【００１１】かかる構成のラジアルラインスロットアンテナ１１０では、前記同軸導波管１１０から給電されたマイクロ波は、前記ディスク状のアンテナ本体１１０Ｂと放射板１１０Ｃとの間を、半径方向に広がりながら進行するが、その際に前記遅相板１１０Ｄの作用により波

長が圧縮される。そこで、このようにして半径方向に進行するマイクロ波の波長に対応して前記スロット１１０ａおよび１１０ｂを同心円状に、かつ相互に直交するように形成しておくことにより、円偏波を有する平面波を前記放射板１１０Ｃに実質的に垂直な方向に放射することができる。

【００１２】かかるラジアルラインスロットアンテナ１１０を使うことにより、前記シャワープレート１０３直下の空間１０１Ｂに均一な高密度プラズマが形成される。このようにして形成された高密度プラズマは電子温度が低く、そのため被処理基板１１４にダメージが生じることがなく、また処理容器１０１の器壁のスパッタリングに起因する金属汚染が生じることもない。

【００１３】図１のプラズマ処理装置１００では、さらに前記処理容器１０１中、前記シャワープレート１０３と被処理基板１１４との間に、外部の処理ガス源（図示せず）から前記処理容器１０１中に形成された処理ガス通路１１２を介して処理ガスを供給する多数のノズル１１３を形成された導体構造物１１１が形成されており、前記ノズル１１３の各々は、供給された処理ガスを、前記導体構造物１１１と被処理基板１１４との間の空間１０１Ｃに放出する。前記導体構造物１１１には、前記隣接するノズル１１３と１１３との間に、前記空間１０１Ｂにおいて形成されたプラズマを前記空間１０１Ｂから前記空間１０１Ｃに拡散により、効率よく通過させるような大きさの開口部が形成されている。

【００１４】そこで、このように前記導体構造物１１１から前記ノズル１１３を介して処理ガスを前記空間１０１Ｃに放出した場合、放出された処理ガスは前記空間１０１Ｂにおいて形成された高密度プラズマにより励起され、前記被処理基板１１４上に、一様なプラズマ処理が、効率的かつ高速に、しかも基板および基板上の素子構造を損傷させることなく、また基板を汚染することなく行われる。一方前記ラジアルラインスロットアンテナ１１０から放射されたマイクロ波は、かかる導体構造物１１１により阻止され、被処理基板１１４を損傷させることはない。

【００１５】

【発明が解決しようとする課題】ところで図１（Ａ），（Ｂ）の従来のプラズマ処理装置１００では、前記シャワープレート１０３と被処理基板１１４との間の間隔が狭いため、前記空間１０１Ｂおよび１０１Ｃにはシャワープレート１０３の径方向への連続的で安定なプラズマ流が形成され、前記被処理基板１１４が大口径基板であっても非常に均一なプラズマ処理が可能になるが、一方で前記処理容器１０１内の圧力が低下した場合、特にシャワープレート１０３の周辺部においてプラズマ密度が低下しやすい問題が生じる。例えば処理容器１０１内の圧力がＡｒ雰囲気中で３００ｍＴｏｒｒ以下に低下した場合、シャワープレート１０３の周辺部においてプラズマ密度が大きく低下する。これは処理容器１０１内の圧力が低下した場合、解離した電子の拡散が促進され、処理容器１０１の内壁面で消滅することに起因するものと考えられる。プラズマのカットオフ密度は７．５×１０^{10} ｃｍ$^{-3}$ であるため、プラズマ密度がかかるカットオフ密度以下に低下するとプラズマを維持することができなくなる。かかるシャワープレート１０３周辺部におけるプラズマ密度の低下は、処理速度の低下を招くだけでなく、マイクロ波が被処理基板１１４に直接に印加されてしまい、損傷を誘起してしまう問題を生じる。

【００１６】そこで、本発明は従来の課題を解決した新規で有用なプラズマ処理装置を提供することを概括的課題とする。

【００１７】本発明のより具体的な課題は、低い処理圧においても被処理基板表面全体にわたり均一な処理が可能なプラズマ処理装置を提供することにある。

【００１８】

【課題を解決するための手段】本発明は上記の課題を、請求項１に記載したように、外壁により画成され、被処理基板を保持する保持台を備えた処理容器と、前記処理容器に結合された排気系と、前記処理容器上に、前記保持台上の被処理基板に対面するように、前記外壁の一部として設けられたマイクロ波透過窓と、前記処理容器中にプラズマガスを供給するプラズマガス供給部と、前記処理容器上に、前記マイクロ波に対応して設けられたマイクロ波アンテナとよりなり、前記マイクロ波透過窓は、前記被処理基板と対面する側の内面が、前記被処理基板表面に一致する平面との間の間隔が、前記マイクロ波透過窓の径方向外側に向って減少する凹面形状を有することを特徴とするプラズマ処理装置により、または請求項２に記載したように、前記間隔は、前記マイクロ波透過窓の径方向外側に向って連続的に減少することを特徴とする請求項１記載のプラズマ処理装置により、または請求項３に記載したように、前記間隔は、前記マイクロ波透過窓の径方向外側に向って滑らかに減少することを特徴とする請求項２記載のプラズマ処理装置により、または請求項４に記載したように、前記間隔は、前記マイクロ波透過窓の径方向外側に向って直線的に減少することを特徴とする請求項２または３記載のプラズマ処理装置により、または請求項５に記載したように、前記間隔は、前記マイクロ波透過窓の径方向外側に向って非直線的に減少することを特徴とする請求項２または３記載のプラズマ処理装置により、または請求項６に記載したように、前記間隔は、前記マイクロ波透過窓の径方向外側に向って階段状に減少することを特徴とする請求項１記載のプラズマ処理装置により、または請求項７に記載したように、前記間隔は、前記マイクロ波透過窓の周辺部においてのみ、前記マイクロ波透過窓の径方向外側に向って減少することを特徴とする請求項１記載のプラズマ処理装置により、または請求項８に記載したように、

前記マイクロ波透過窓は、前記内面に対向する外面が平坦面よりなることを特徴とする請求項１～７のうち、いずれか一項記載のプラズマ処理装置により、または請求項９に記載したように、前記マイクロ波透過窓は、内部にプラズマガス通路を有し、前記処理容器中にプラズマガスを放出する前記プラズマガス供給部を構成することを特徴とする請求項１～８のうち、いずれか一項記載のプラズマ処理装置により、または請求項１０に記載したように、前記マイクロ波透過窓は、前記プラズマガス通路に連通する複数の開口部を有することを特徴とする請求項９記載のプラズマ処理装置により、または請求項１１に記載したように、マイクロ波透過窓は、前記処理容器の外壁の一部を構成するカバープレートと、前記カバープレートに密接して設けられ、前記プラズマガス通路とこれに連通する複数の開口部とを有するシャワープレートよりなることを特徴とする請求項９記載のプラズマ処理装置により、または請求項１２に記載したように、前記マイクロ波透過窓は緻密なセラミックよりなることを特徴とする請求項８または１１記載のプラズマ処理装置により、または請求項１３に記載したように、前記マイクロ波透過窓は、多孔質媒体より構成されることを特徴とする請求項９記載のプラズマ処理装置により、または請求項１４に記載したように、前記マイクロ波透過窓は、前記処理容器の一部を構成するカバープレートと、前記カバープレートに密接して設けられた多孔質媒体よりなるシャワープレートとよりなることを特徴とする請求項９記載のプラズマ処理装置により、または請求項１５に記載したように、前記多孔質媒体は、焼結セラミックよりなることを特徴とする請求項１３または１４記載のプラズマ処理装置により、または請求項１６に記載したように、前記プラズマガス供給部は、前記処理容器外壁に形成された、プラズマガス源に接続可能な管よりなることを特徴とする請求項１～８のうち、いずれか一項記載のプラズマ処理装置により、または請求項１７に記載したように、前記マイクロ波透過窓は、緻密なセラミックよりなることを特徴とする請求項１６記載のプラズマ処理装置により、または請求項１８に記載したように、さらに、前記被処理基板と前記プラズマガス源との間に、処理ガス供給部を設けたことを特徴とする請求項１～１７のうち、いずれか一項記載のプラズマ処理装置により、または請求項１９に記載したように、前記処理ガス供給部は、プラズマを通過させるプラズマ通路と、処理ガス源に接続可能な処理ガス通路と、前記処理ガス通路に連通した多数のノズル開口部とを有することを特徴とする請求項１８記載のプラズマ処理装置により、または請求項２０に記載したように、さらに前記保持台に接続された高周波電源を含むことを特徴とする請求項１～１９のうち、いずれか一項記載のプラズマ処理装置により、または請求項２１に記載したように、前記マイクロ波アンテナはラジアルラインスロットアンテナよりなることを特徴とする請求項１～２０のうち、いずれか一項記載のプラズマ処理装置により、解決する。

［作用］本発明によれば、前記シャワープレートの被処理基板に対面する側に凹面を形成することにより、被処理基板周辺部において高密度プラズマが形成されるシャワープレート下面と被処理基板表面との間の間隔が減少し、シャワープレート周辺部におけるプラズマ密度の低下が補償される。その結果、エッチングなど低圧におけるプラズマ処理を行った場合にも被処理基板表面近傍において安定で均一なプラズマが維持される。またかかる構成により、プラズマの着火も促進される。かかる凹面形成によるプラズマの安定化は、被処理基板とプラズマガス供給部の間に処理ガス供給部を設けた構成のみならず、処理ガス供給部を省略した構成に対しても適用可能である。

【００１９】かかる凹面を有するシャワープレートとしては、プラズマガス通路とこれに連通した多数の開口部を形成された緻密なセラミック部材を使うことが可能であるが、前記緻密なセラミック部材の代わりに多孔質セラミック部材を使うことも可能である。これらのシャワープレートは、処理容器外壁の一部をなしプラズマ透過窓を構成する緻密なカバープレートに密接して設けられるが、本発明においてはさらにマイクロ波透過窓自体に前記凹部を形成し、プラズマガスを別途、シャワープレートを使わずに、管などにより前記処理室中に導入することも可能である。

【００２０】本発明によるシャワープレートあるいはマイクロ波透過窓では、前記凹面をなす内面に対向する外面が平坦面であると、マイクロ波アンテナとの密着が容易に確保でき、アンテナを介したシャワープレートの冷却が可能となるため有利である。

【００２１】

【発明の実施の形態】［第１実施例］図２（Ａ），（Ｂ）は、本発明の第１実施例によるマイクロ波プラズマ処理装置１０の構成を示す。

【００２２】図２（Ａ）を参照するに、前記マイクロ波プラズマ処理装置１０は処理容器１１と、前記処理容器１１内に設けられ、被処理基板１２を静電チャックにより保持する好ましくは熱間等方圧加圧法（ＨＩＰ）により形成されたＡｌＮもしくはAl_2O_3よりなる保持台１３とを含み、前記処理容器１１内には前記保持台１３を囲む空間１１Ａに等間隔に、すなわち前記保持台１３上の被処理基板１２に対して略軸対称な関係で少なくとも二箇所、好ましくは三箇所以上に排気ポート１１ａが形成されている。前記処理容器１１は、かかる排気ポート１１ａを介して不等ピッチ不等傾角スクリューポンプ等により、排気・減圧される。

【００２３】前記処理容器１１は好ましくはＡｌを含有するオーステナイトステンレス鋼よりなり、内壁面には酸化処理により酸化アルミニウムよりなる保護膜が形成

されている。また前記処理容器１１の外壁のうち前記被処理基板１２に対応する部分には、ＨＩＰ法により形成された緻密なAl_2O_3よりなり多数のノズル開口部１４Ａを形成されたディスク状のシャワープレート１４が、前記外壁の一部として形成される。かかるＨＩＰ法により形成されたAl_2O_3シャワープレート１４はY_2O_3を焼結助剤として使って形成され、気孔率が０．０３％以下で実質的に気孔やピンホールを含んでおらず、３０Ｗ／ｍ・Ｋに達する、セラミックとしては非常に大きな熱伝導率を有する。

【００２４】前記シャワープレート１４は前記処理容器１１上にシールリング１１ｓを介して装着され、さらに前記シャワープレート１４上には同様なＨＩＰ処理により形成された緻密なAl_2O_3よりなるカバープレート１５が、シールリング１１ｔを介して設けられている。前記シャワープレート１４の前記カバープレート１５と接する側には前記ノズル開口部１４Ａの各々に連通しプラズマガス流路となる凹部１４Ｂが形成されており、前記凹部１４Ｂは前記シャワープレート１４の内部に形成され、前記処理容器１１の外壁に形成されたプラズマガス入口１１ｐに連通する別のプラズマガス流路１４Ｃに連通している。

【００２５】前記シャワープレート１４は前記処理容器１１の内壁に形成された張り出し部１１ｂにより保持されており、前記張り出し部１１ｂのうち、前記シャワープレート１４を保持する部分には異常放電を抑制するために丸みが形成されている。

【００２６】そこで、前記プラズマガス入口１１ｐに供給されたＡｒやＫｒ等のプラズマガスは前記シャワープレート１４内部の流路１４Ｃおよび１４Ｂを順次通過した後、前記開口部１４Ａを介して前記シャワープレート１４直下の空間１１Ｂ中に一様に供給される。

【００２７】前記カバープレート１５上には、前記カバープレート１５に密接し図３（Ｂ）に示す多数のスロット１６ａ，１６ｂを形成されたディスク状のスロット板１６と、前記スロット板１６を保持するディスク状のアンテナ本体１７と、前記スロット板１６と前記アンテナ本体１７との間に挟持されたAl_2O_3，Si_3N_4，ＳｉＯＮあるいはSiO_2等の低損失誘電体材料よりなる遅相板１８とにより構成されたラジアルラインスロットアンテナ２０が設けられている。前記ラジアルスロットラインアンテナ２０は前記処理容器１１上にシールリング１１ｕを介して装着されており、前記ラジアルラインスロットアンテナ２０には矩形あるいは円形断面を有する同軸導波管２１を介して外部のマイクロ波源（図示せず）より周波数が２．４５ＧＨｚあるいは８．３ＧＨｚのマイクロ波が供給される。供給されたマイクロ波は前記スロット板１６上のスロット１６ａ，１６ｂから前記カバープレート１５およびシャワープレート１４を介して前記処理容器１１中に放射され、前記シャワープレート１４直下の空間１１Ｂにおいて、前記開口部１４Ａから供給されたプラズマガス中にプラズマを励起する。その際、前記カバープレート１５およびシャワープレート１４はAl_2O_3により形成されており、効率的なマイクロ波透過窓として作用する。その際、前記プラズマガス流路１４Ａ～１４Ｃにおいてプラズマが励起されるのを回避するため、前記プラズマガスは、前記流路１４Ａ～１４Ｃにおいて約６６６６Ｐａ～１３３３２Ｐａ（約５０～１００Ｔｏｒｒ）の圧力に保持される。

【００２８】前記ラジアルラインスロットアンテナ２０と前記カバープレート１５との密着性を向上させるため、本実施例のマイクロ波プラズマ処理装置１０では前記スロット板１６に係合する前記処理容器１１の上面の一部にリング状の溝１１ｇが形成されており、かかる溝１１ｇを、これに連通した排気ポート１１Ｇを介して排気することにより、前記スロット板１６とカバープレート１５との間に形成された隙間を減圧し、大気圧により、前記ラジアルラインスロットアンテナ２０を前記カバープレート１５にしっかりと押し付けることが可能になる。かかる隙間には、前記スロット板１６に形成されたスロット１６ａ，１６ｂが含まれるが、それ以外にもカバープレート１５表面の微細な凹凸など様々な理由により隙間が形成されることがある。かかる隙間は、前記ラジアルラインスロットアンテナ２０と処理容器１１との間のシールリング１１ｕにより封止されている。

【００２９】さらに前記排気ポート１１Ｇおよび溝１５ｇを介して前記スロット板１６と前記カバープレート１５との間の隙間に分子量の小さい不活性気体を充填することにより、前記カバープレート１５から前記スロット板１６への熱の輸送を促進することができる。かかる不活性気体としては、熱伝導率が大きくしかもイオン化エネルギの高いＨｅを使うのが好ましい。前記隙間にＨｅを充填する場合には、０．８気圧程度の圧力に設定するのが好ましい。図３の構成では、前記溝１５ｇの排気および溝１５ｇへの不活性気体の充填のため、前記排気ポート１１Ｇにバルブ１１Ｖが接続されている。

【００３０】前記同軸導波管２１Ａのうち、外側の導波管２１Ａは前記ディスク状のアンテナ本体１７に接続され、中心導体２１Ｂは、前記遅波板１８に形成された開口部を介して前記スロット板１６に接続されている。そこで前記同軸導波管２１Ａに供給されたマイクロ波は、前記アンテナ本体１７とスロット板１６との間を径方向に進行しながら、前記スロット１６ａ，１６ｂより放射される。

【００３１】図２（Ｂ）は前記スロット板１６上に形成されたスロット１６ａ，１６ｂを示す。

【００３２】図２（Ｂ）を参照するに、前記スロット１６ａは同心円状に配列されており、各々のスロット１６ａに対応して、これに直行するスロット１６ｂが同じく同心円状に形成されている。前記スロット１６ａ，１６

ｂは、前記スロット板１６の半径方向に、前記遅相板１８により圧縮されたマイクロ波の波長に対応した間隔で形成されており、その結果マイクロ波は前記スロット板１６から略平面波となって放射される。その際、前記スロット１６ａおよび１６ｂを相互の直交する関係で形成しているため、このようにして放射されたマイクロ波は、二つの直交する偏波成分を含む円偏波を形成する。

【００３３】本実施例のプラズマ処理装置１０では、前記シャワープレート１４の前記被処理基板１２に対面する側の表面が凹面形状の湾曲面を形成しており、その結果前記シャワープレート１４と被処理基板１２の表面に一致する平面との間の間隔Ｄが、前記シャワープレート１４の半径方向上外方に向って滑らかに減少する。すなわち前記凹面形状は軸対称な曲面により画成されており、前記間隔Ｄが前記被処理基板１２の周辺部において減少するため、かかる被処理基板周辺部におけるプラズマ密度の低下の問題が解消される。

【００３４】これにより、前記プラズマ処理装置１０ではドライエッチングなど、低圧環境化で行う必要のあるプラズマ処理を行ってもプラズマ密度がカットオフ密度以下に低下することがなく、プラズマが安定に維持され、被処理基板１２周辺部におけるプラズマの消滅やマイクロ波による基板の損傷、あるいは処理速度の低下などの問題を回避することができる。

【００３５】さらに図２（Ａ）のプラズマ処理装置１０では、前記アンテナ本体１７上に、冷却水通路１９Ａを形成された冷却ブロック１９が形成されており、前記冷却ブロック１９を前記冷却水通路１９Ａ中の冷却水により冷却することにより、前記シャワープレート１４に蓄積された熱を、前記ラジアルラインスロットアンテナ２０を介して吸収する。前記冷却水通路１９Ａは前記冷却ブロック１９上においてスパイラル状に形成されており、好ましくはH_2ガスをバブリングすることで溶存酸素を排除して且つ酸化還元電位を制御した冷却水が通される。

【００３６】また、図２（Ａ）のマイクロ波プラズマ処理装置１０では、前記処理容器１１中、前記シャワープレート１４と前記保持台１３上の被処理基板１２との間に、前記処理容器１１の外壁に設けられた処理ガス注入口１１ｒから処理ガスを供給されこれを多数の処理ガスノズル開口部３１Ｂ（図３参照）から放出する格子状の処理ガス通路３１Ａを有する処理ガス供給構造３１が設けられ、前記処理ガス供給構造３１と前記被処理基板１２との間の空間１１Ｃにおいて、所望の均一な基板処理がなされる。かかる基板処理には、プラズマ酸化処理、プラズマ窒化処理、プラズマ酸窒化処理、プラズマＣＶＤ処理等が含まれる。また、前記処理ガス供給構造３１から前記空間１１ＣにC_4F_8、C_5F_8またはC_4F_6などの解離しやすいフルオロカーボンガスや、Ｆ系あるいはＣｌ系等のエッチングガスを供給し、前記保持台１３に高周波電源１３Ａから高周波電圧を印加することにより、前記被処理基板１２に対して反応性イオンエッチングを行うことが可能である。

【００３７】本実施例によるマイクロ波プラズマ処理装置１０では、前記処理容器１１の外壁は１５０°Ｃ程度の温度に加熱しておくことにより、処理容器内壁への反応副生成物等の付着が回避され、一日に一回程度のドライクリーニング行うことで、定常的に、安定して運転することが可能である。

【００３８】図４は、図２（Ａ）の構成における処理ガス供給構造３１の構成を示す底面図である。

【００３９】図４を参照するに、前記処理ガス供給構造３１は例えばＭｇを含んだＡｌ合金やＡｌ添加ステンレススチール等の導電体より構成されており、前記格子状処理ガス通路３１Ａは前記処理ガス注入口１１ｒに処理ガス供給ポート３１Ｒにおいて接続され、下面形成された多数の処理ガスノズル開口部３１Ｂから処理ガスを前記空間１１Ｃに均一に放出する。また、前記処理ガス供給構造３１には、隣接する処理ガス通路３１Ａの間にプラズマやプラズマ中に含まれる処理ガスを通過させる開口部３１Ｃを形成されている。前記処理ガス供給構造３１をＭｇ含有Ａｌ合金により形成する場合には、表面に弗化物膜を形成しておくのが好ましい。また前記処理ガス供給構造３１をＡｌ添加ステンレススチールにより形成する場合には、表面に酸化アルミニウムの不動態膜を形成しておくのが望ましい。本発明によるプラズマ処理装置１０では、励起される励起されるプラズマ中の電子温度が低いためプラズマの入射エネルギが小さく、かかる処理ガス供給構造３１がスパッタリングされて被処理基板１２に金属汚染が生じる問題が回避される。前記処理ガス供給構造３１は、アルミナ等のセラミックスにより形成することも可能である。

【００４０】前記格子状処理ガス通路３１Ａおよび処理ガスノズル開口部３１Ｂは図４に破線で示した被処理基板１２よりもやや大きい領域をカバーするように設けられている。かかる処理ガス供給構造３１を前記シャワープレート１４と被処理基板１２との間に設けることにより、原料ガスやエッチングガスなどの処理ガスをプラズマ励起し、かかるプラズマ励起された処理ガスにより、均一に処理することが可能になる。

【００４１】前記処理ガス供給構造３１を金属等の導体により形成する場合には、前記格子状処理ガス通路３１Ａ相互の間隔を前記マイクロ波の波長よりも短く設定することにより、前記処理ガス供給構造３１はマイクロ波の短絡面を形成する。この場合にはプラズマのマイクロ波励起は前記空間１１Ｂ中においてのみ生じ、前記被処理基板１２の表面を含む空間１１Ｃにおいては前記励起空間１１Ｂから拡散してきたプラズマにより、処理ガスが活性化される。

【００４２】本実施例によるマイクロ波プラズマ処理装

置１０では、処理ガス供給構造３１を使うことにより処理ガスの供給が一様に制御されるため、処理ガスの被処理基板１２表面における過剰解離の問題を解消することができ、被処理基板１２の表面にアスペクト比の大きい構造が形成されている場合でも、所望の基板処理を、かかる高アスペクト構造の奥にまで実施することが可能である。すなわち、マイクロ波プラズマ処理装置１０は、設計ルールの異なる多数の世代の半導体装置の製造に有効である。

【００４３】図５のプラズマ処理装置１０Ｂでは、前記処理ガス供給構造１３から様々な酸化ガスや窒化ガス、原料ガスやエッチングガスを導入することにより、前記被処理基板１２の表面の全面に、前記被処理基板１２が大口径基板であっても様々な高品質膜を低温で、均一に堆積し、あるいは前記表面を均一にエッチングすることが可能である。

【００４４】図４は、前記シャワープレート１４の様々な変形例によるシャワープレート１４$_1$～１４$_4$の構成を示す。

【００４５】図４を参照するに、前記シャワープレート１４$_1$は前記被処理基板１２に対面する側に円錐形状の凹面を有するのに対し、前記シャワープレート１４$_2$は円錐台形状の凹面を有するのがわかる。さらに前記シャワープレート１４$_3$では円形の凹部が段差形状を形成しており、前記シャワープレート１４$_4$では複数の段差形状凹部が形成されている。これらの凹部はいずれも前記シャワープレートの中心軸に対して軸対称に形成されており、前記中心軸の回りで均一な処理が保証される。

［第２実施例］図５は、本発明の第２実施例によるプラズマ処理装置１０Ａの構成を示す。ただし図５中、先に説明した部分には同一の参照符号を付し、説明を省略する。

【００４６】図５を参照するに、プラズマ処理装置１０Ａは前記プラズマ処理装置１０と類似した構成を有し、前記被処理基板１２とシャワープレート１４との間隔Ｄが、前記シャワープレート１４の半径方向上外方に向って減少するが、前記プラズマ処理装置１０Ａでは前記処理ガス供給部１３が撤去されている。

【００４７】かかる構成のプラズマ処理装置１０Ｂでは、前記下段シャワープレート３１が省略されているためプラズマガスとは別に処理ガスを供給して成膜やエッチングを行うことはできないが、前記シャワープレート１４からプラズマガスとともに酸化ガスあるいは窒化ガスを供給することにより、被処理基板表面に酸化膜や窒化膜、あるいは酸窒化膜を形成することが可能である。本実施例のプラズマ処理装置１０Ａでは、構成が簡素化され、製造費用を大きく低減することが可能である。

【００４８】本実施例においても、前記間隔Ｄが被処理基板１２の周辺部において減少するため、被処理基板１２周辺部におけるプラズマ密度の低下が補償され、プラズマが安定に維持され、被処理基板１２周辺部におけるプラズマの消滅やマイクロ波による基板の損傷、あるいは処理速度の低下などの問題を回避することができる。

【００４９】図５のプラズマ処理装置１０Ａでは、特に被処理基板１２の酸化処理や窒化処理、酸窒化処理などを、前記被処理基板が大口径基板であっても、低温で、効率的に、しかも均一に、安い費用で行うことが可能である。

【００５０】本実施例においても、前記シャワープレート１４の代わりに図４で説明したシャワープレート１４$_1$～１４$_3$を使うことが可能である。

［第３実施例］図６は本発明の第３実施例によるプラズマ処理装置１０Ｂの構成を示す。ただし図６中、先に説明した部分に対応する部分には同一の参照符号を付し、説明を省略する。

【００５１】図６を参照するに、本実施例においては前記シャワープレート１４の代わりに焼結アルミナなど、多孔質セラミックよりなるシャワープレート１４Ｐを使う。

【００５２】前記シャワープレート１４Ｐ中にはシャワープレート１４中におけるようなシャワー開口部１４Ａは形成されていないが、プラズマガス供給ポート１１Ｐに接続されたプラズマガス供給路１４Ｃおよび１４Ｂが形成されており、供給されたプラズマガスは、前記プラズマガス供給路１４Ｂから前記多孔質シャワープレート１４Ｐ中の気孔を通って、前記空間１１Ｂへと、一様に放出される。

【００５３】本実施例においても、前記シャワープレート１４Ｐの下面は軸対称な凹面を形成し、前記下面と被処理基板１２の表面との間の間隔Ｄは、被処理基板１２の周辺部に向って減少する。このため、図６の構成においては前記被処理基板１２の周辺部におけるプラズマ密度の低下が補償され、プラズマが安定に維持され、被処理基板１２周辺部におけるプラズマの消滅やマイクロ波による基板の損傷、あるいは処理速度の低下などの問題を回避することができる。

【００５４】図６のプラズマ処理装置１０Ｂでは、前記処理ガス供給構造１３から様々な酸化ガスや窒化ガス、原料ガスやエッチングガスを導入することにより、前記被処理基板１２の表面の全面に様々な高品質膜を低温で、均一に堆積し、あるいは前記表面を均一にエッチングすることが可能である。

【００５５】本実施例においても、前記多孔質シャワープレート１４Ｐの凹面として、図４に示した様々な凹面を形成することができる。

［第４実施例］図７は、本発明の第４実施例によるプラズマ処理装置１０Ｃの構成を示す。ただし図７中、先に説明した部分には同一の参照符号を付し、説明を省略する。

【００５６】図７を参照するに、本実施例のプラズマ処

理装置１０Ｃは、先のプラズマ処理装置１０Ｂと同様な構成を有するが、前記下段シャワープレート３１が撤去されている。また、前記シャワープレート１４を保持する前記張り出し部１１ｂの全面に丸みが形成されている。

【００５７】かかる構成のプラズマ処理装置１０Ｃでは、前記下段シャワープレート３１が省略されているためプラズマガスとは別に処理ガスを供給して成膜やエッチングを行うことはできないが、前記シャワープレート１４からプラズマガスとともに酸化ガスあるいは窒化ガスを供給することにより、被処理基板表面に酸化膜や窒化膜、あるいは酸窒化膜を形成することが可能である。

【００５８】本実施例においても、前記シャワープレート１４Ｐの下面は軸対称な凹面を形成し、前記下面と被処理基板１２の表面との間の間隔Ｄは、被処理基板１２の周辺部に向って減少する。このため、図７の構成においては前記被処理基板１２の周辺部におけるプラズマ密度の低下が補償され、プラズマが安定に維持され、被処理基板１２周辺部におけるプラズマの消滅やマイクロ波による基板の損傷、あるいは処理速度の低下などの問題を回避することができる。

【００５９】図７のプラズマ処理装置１０Ｃでは、特に被処理基板１２の酸化処理や窒化処理、酸窒化処理などを、前記被処理基板が大口径基板であっても、低温で、効率的に、しかも均一に、安い費用で行うことが可能である。

【００６０】本実施例のシャワープレート１４Ｐにおいても、図４に示した様々な凹面を使うことができる。

［第５実施例］図８は、本発明の第５実施例によるプラズマ処理装置１０Ｄの構成を示す。ただし図８中、先に説明した部分には同一の参照符号を付し、説明を省略する。

【００６１】図８を参照するに、実施例においては図６の実施例における多孔質シャワープレート１４Ｐおよびカバープレート１５が撤去され、かわりに前記被処理基板１２に対面する側に凹面を有する緻密なセラミックよりなるマイクロ波透過窓１４Ｑが設けられる。前記マイクロ波透過窓１４は、誘電損失の少ない材料、例えばＨＩＰ処理したアルミナなどにより形成することができる。

【００６２】図８の構成では、前記マイクロ波透過窓１４Ｑは前記カバープレート１５の機能を果たすが、図６の実施例におけるプラズマガス通路１４Ｃやこれに連通する開口部１４Ａは形成されておらず、別に処理容器１１の外壁に、管１１Ｐよりなるプラズマガス導入部が形成されている。また前記マイクロ波透過窓１４Ｑ上にはラジアルラインスロットアンテナ２０が密接して設けられている。前記プラズマガス導入管１１Ｐは、前記被処理基板１２の周囲に対称的に配設されるのが好ましい。

【００６３】かかる構成では、前記マイクロ波透過窓１４Ｑの下面は軸対称な凹面を形成し、前記下面と被処理基板１２の表面との間の間隔Ｄは、被処理基板１２の周辺部に向って減少する。このため、図８の構成においては前記被処理基板１２の周辺部におけるプラズマ密度の低下が補償され、プラズマが安定に維持され、被処理基板１２周辺部におけるプラズマの消滅やマイクロ波による基板の損傷、あるいは処理速度の低下などの問題を回避することができる。

【００６４】図８のプラズマ処理装置１０Ｄでは、特に被処理基板１２の酸化処理や窒化処理、酸窒化処理などを、前記被処理基板が大口径基板であっても、低温で、効率的に、しかも均一に、安い費用で行うことが可能である。特にプラズマガスを導入するための構成が簡素化され、費用の低減に寄与する。

【００６５】本実施例のプラズマ透過窓においても、図４に示した様々な凹面を使うことができる。

［第６実施例］図９は、本発明の第６実施例によるプラズマ処理装置１０Ｅの構成を示す。ただし図９中、先に説明した部分には同一の参照符号を付し、説明を省略する。

【００６６】図９を参照するに、本実施例のプラズマ処理装置１０Ｅは先のプラズマ処理装置１０Ｄと類似した構成を有するが、前記処理ガス供給構造３１が撤去されている。

【００６７】かかる構成によれば、前記プラズマガス導入管１１ＰよりＫｒやＡｒなどの不活性ガスとO_2ガスなどの酸化性ガスあるいはNH_3ガスあるいはN_2とH_2の混合ガスなど窒化性ガスを供給することにより、前記被処理基板１２の表面に高品質の酸化膜や窒化膜、あるいは酸窒化膜を、低温で効率よく形成することが可能になる。

【００６８】その際、本実施例では前記マイクロ波透過窓１４Ｑの下面と被処理基板１２との間の間隔Ｄが前記被処理基板１２の周辺部において減少しているため、前記被処理基板１２周辺部において十分なプラズマ密度が確保され、前記被処理基板１２の処理が、均一に行われる。

【００６９】本実施例のマイクロ波窓１４Ｑにおいても、図４に示した様々な凹面を使うことができる。

［第７実施例］図１０は、本発明の第７実施例によるプラズマ処理装置１０Ｆの構成を示す。ただし図１０中、先に説明した部分には同一の参照符号を付し、説明を省略する。

【００７０】図１０を参照するに、本実施例では前記誘電体窓１４Ｑの代わりに一様な厚さの誘電体窓１４Ｑ’により構成されている。

【００７１】かかる誘電体窓１４Ｑ’では、凹面を形成する下面に対応して、上面が凸面を形成する。そこで図１０のプラズマ処理装置１０では、平坦な前記ラジアルラインスロットアンテナ２０の代わりに前記凸面に対応

した凹面を有するラジアルラインスロットアンテナ２０’を使う。すなわち、前記ラジアルラインスロットアンテナ２０’は凹面を形成するスロット板１６’を有し、前記スロット板１６’上には凹面を形成するアンテナ本体１７’が、間に湾曲した遅相板１８’を介して装着されている。

【００７２】かかる構成のプラズマ処理装置１０Ｆにおいても、前記被処理基板１２の周辺部におけるプラズマ密度の低下を補償でき、前記処理ガス供給部３１より様々な処理ガスを供給することにより、被処理基板１２の全面にわたり、酸化や窒化、酸窒化、さらに様々な層の堆積およびエッチングなど、様々なプラズマ処理を、均一に、かつ安定に行うことが可能になる。

［第８実施例］図１１は、本発明の第８実施例によるプラズマ処理装置１０Ｇの構成を示す。ただし図１１中、先に説明した部分には同一の参照符号を付し、説明を省略する。

【００７３】図１１を参照するに、本実施例のプラズマ処理装置１０Ｇは先の実施例のプラズマ処理装置１０Ｆと同様な構成を有するが、本実施例では前記処理ガス供給部３１が撤去されている。

【００７４】かかる構成のプラズマ処理装置１０Ｇにおいても、前記被処理基板１２の周辺部におけるプラズマ密度の低下を補償でき、被処理基板１２の全面にわたり、酸化や窒化、酸窒化などの均一なプラズマ処理を安定に行うことが可能になる。

【００７５】本発明は上記特定の実施例に限定されるものではなく、特許請求の範囲に記載した本発明の要旨内において様々な変形・変更が可能である。

【００７６】

【発明の効果】本発明によれば、被処理基板の周辺部におけるプラズマ密度の低下を補償でき、低圧処理においてもプラズマが維持され、安定なプラズマ処理が可能になる。

【図面の簡単な説明】

【図１】（Ａ），（Ｂ）は、従来のラジアルラインスロットアンテナを使ったマイクロ波プラズマ処理装置の構成を示す図である。

【図２】（Ａ），（Ｂ）は、本発明の第１実施例によるプラズマ処理装置の構成を示す図である。

【図３】図２（Ａ），（Ｂ）のプラズマ処理装置で使われる処理ガス供給構造の構成を示す底面図である。

【図４】図２（Ａ），（Ｂ）のプラズマ処理装置の様々な変形例を示す図である。

【図５】本発明の第２実施例によるプラズマ処理装置の構成を示す図である。

【図６】本発明の第３実施例によるプラズマ処理装置の構成を示す図である。

【図７】本発明の第４実施例によるプラズマ処理装置の構成を示す図である。

【図８】本発明の第５実施例によるプラズマ処理装置の構成を示す図である。

【図９】本発明の第６実施例によるプラズマ処理装置の構成を示す図である。

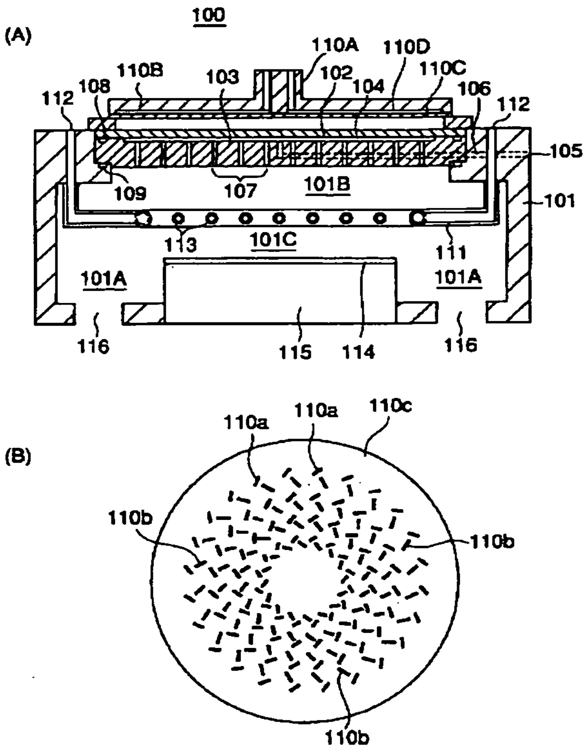
【図１０】本発明の第７実施例によるプラズマ処理装置の構成を示す図である。

【図１１】本発明の第８実施例によるプラズマ処理装置の構成を示す図である。

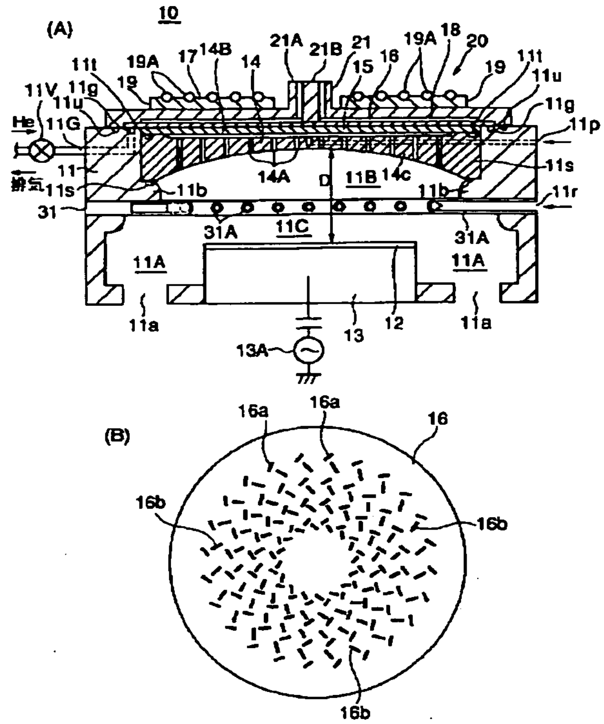
【符号の説明】

１０，１０Ａ～１０Ｇ，１００　プラズマ処理装置
１１　処理容器
１１ａ　排気ポート
１１ｂ　張り出し部
１１ｐ　プラズマガス供給ポート
１１ｒ　処理ガス供給ポート
１１Ａ，１１Ｂ，１１Ｃ　空間
１１Ｇ　減圧およびＨｅ供給ポート
１１Ｐ　プラズマガス導入口
１２　被処理基板
１３　保持台
１３Ａ　高周波電源
１４　シャワープレート
１４Ｐ　多孔質シャワープレート
１４Ａ　プラズマガスノズル開口部
１４Ｂ，１４Ｃ　プラズマガス通路
１４Ｑ、１４Ｑ’　マイクロ波透過窓
１５　カバープレート
１６，１６’　スロット板
１６ａ，１６ｂ　スロット開口部
１７，１７’　アンテナ本体
１８，１８’　遅波板
１８Ａ，１８Ｂ　リング状部材
１９　冷却ブロック
１９Ａ　冷却水通路
２０，２０’　ラジアルラインアンテナ
２１　同軸導波管
２１Ａ　外側導波管
２１Ｂ　内側給電線
３１　処理ガス供給構造
３１Ａ　処理ガス通路
３１Ｂ　処理ガスノズル
３１Ｃ　プラズマ拡散通路
３１Ｒ　処理ガス供給ポート

【図１】


(A)
100
110A
110D
110B
103
102
104
110C
112
108
106
112
105
109
107
101B
101
113
101C
111
101A
101A
116
115
114
116
(B)
110a
110a
110c
110b
110b
110b

【図２】


(A)
10
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21B
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19A
18
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14B
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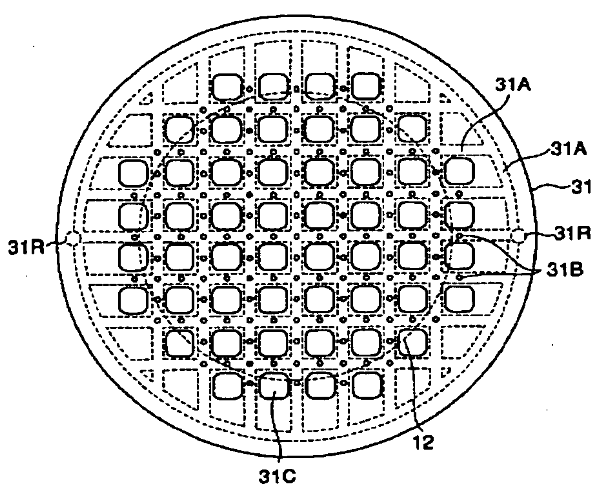
16
19
111
11V
11g
19
11u
11u
11g
He
11G
11p
11
14A
D
11B
14c
11s
排気
11s
11b
11b
11r
31
31A
11C
31A
11A
11A
11a
13
12
11a
13A
(B)
16a
16a
16
16b
16b
16b

【図３】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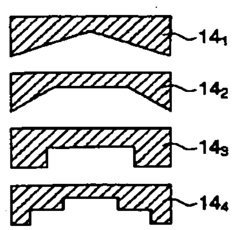
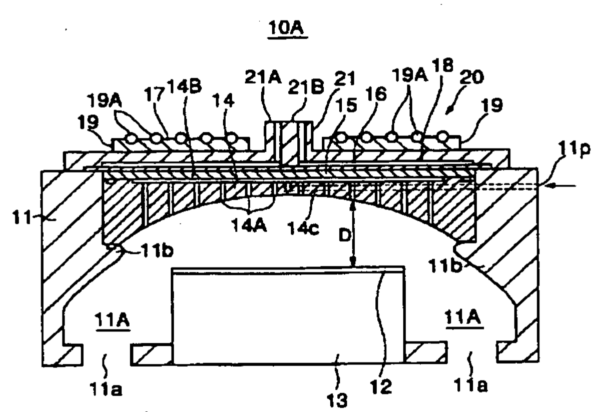
31A
31
31R
31R
31B
12
31C

【図４】


14_1
14_2
14_3
14_4

【図５】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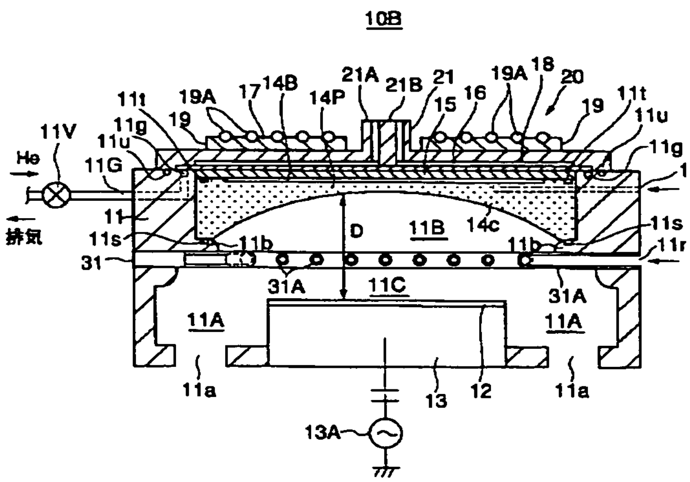
21A
21B
21
19A
18
20
19A
17
14B
14
15
16
19
19
11p
11
14A
14c
D
11b
11b
11A
11A
11a
13
12
11a

【図６】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11t
19A
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14P
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21B
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15
16
19A
18
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11t
11u
11V
11g
19
19
11u
11g
He
11G
11p
11
D
11B
14c
11s
排気
11s
11b
11b
11r
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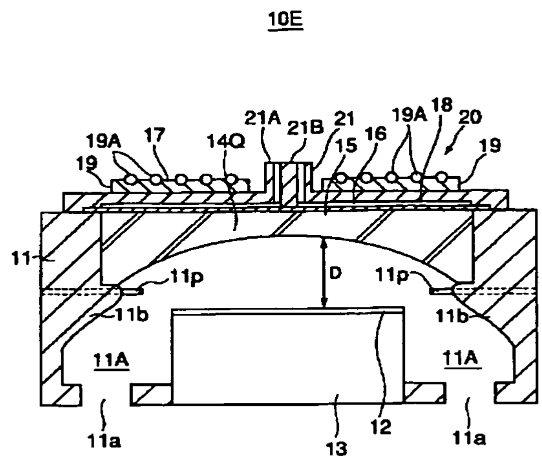
31A
11C
31A
11A
11A
11a
13
12
11a
13A

【図９】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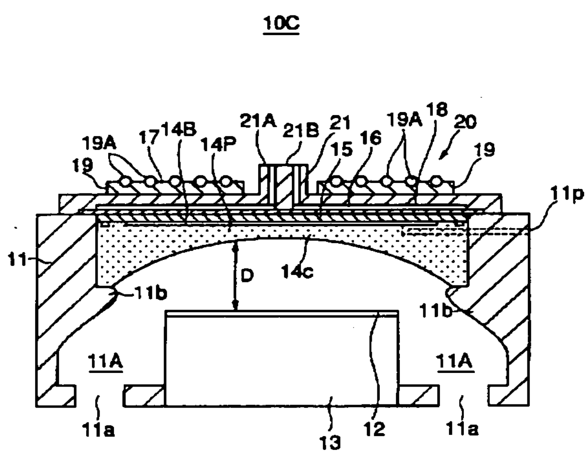
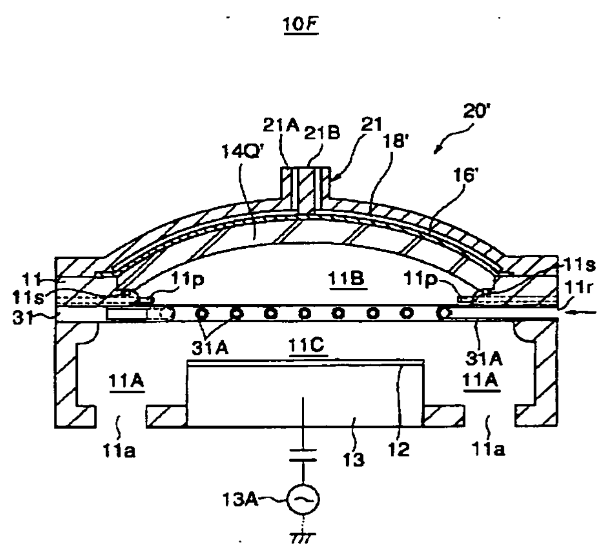
21A
21B
21
19A
18
20
19A
17
14Q
15
16
19
19
11
11p
D
11p
11b
11b
11A
11A
11a
13
12
11a

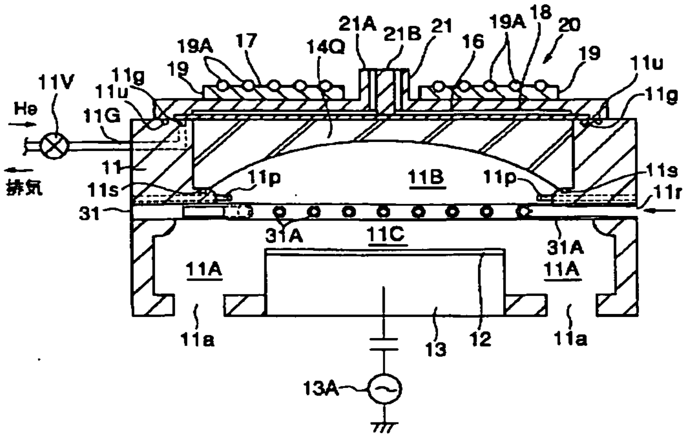
【図７】


10C
21A
21B
21
19A
18
20
19A
17
14B
14P
15
16
19
19
11p
11
D
14c
11b
11b
11A
11A
11a
13
12
11a

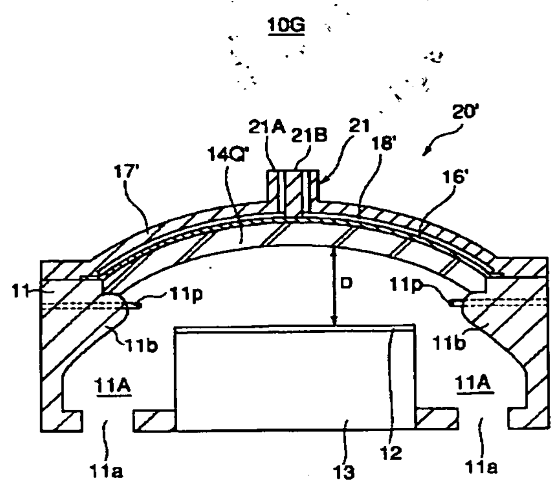
【図１０】


10F
20'
21A
21B
21
18'
14Q'
16'
11
11s
11s
11p
11B
11p
11r
31
31A
11C
31A
11A
11A
11a
13
12
11a
13A

【図８】



【図１１】



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4K030 BA38 BA42 EA05 FA01 JA03 KA30 KA46 LA18
5F004 AA01 BA20 BB11 BB14 BB18 BB28 BC08 BD04 DA00 DA01 DA02 DA03 DA04 DA05 DA11 DA12 DA13 DA14 DA15 DA16 DA17 DA18 DA19 DA20 DA29
5F045 AA09 AB32 AB33 AB34 AE23 AE25 BB02 DP03 DQ10 EF04 EF05 EH02 EH03